A. M. A.
ARCHIVES OF
OPHTHALMOLOGY

Continuing the Publication
FOUNDED BY HERMAN KNAPP, 1869

EDITORIAL BOARD

FRANCIS HEED ADLER, Chief Editor
313 South Seventeenth Street, Philadelphia 3

WILLIAM ZENTMAYER, Philadelphia
W. L. BENEDICT, Rochester, Minn.
KENNETH C. SWAN, Portland, Ore.
WILLIAM F. HUGHES Jr., Chicago
DAVID G. COGAN, Boston
JONAS S. FRIEDENWALD, Baltimore
JOHN H. DUNNINGTON, New York

ASSOCIATES:

Alson E. Braley
F. Phinizy Calhoun Jr.
A. Gerard DeVoe
Trygve Gundersen
Joseph S. Haas
John E. Harris
John M. McLean
Paul W. Miles
Frank Payne
Ludwig von Sallmann
Henry P. Wagener
Maynard C. Wheeler

INDEX NUMBER

DECEMBER 1953

VOLUME 50 NUMBER 6

Published Monthly by
AMERICAN MEDICAL ASSOCIATION
535 NORTH DEARBORN STREET • CHICAGO 10, ILLINOIS

Entered as Second Class Matter Feb. 7, 1929, at the Postoffice at Chicago, Under the Act of March 3, 1879. Annual Subscription, $12.00

TABLE OF CONTENTS FIRST PAGE

A SCIENTIFIC CORNER

WHERE OPTICAL PROBLEMS ARE DISCUSSED AND
THE SOLUTIONS, AS SOLVED BY EXPERIENCE, INDICATED!

PRESENTED BY

THE HOUSE OF VISION, INC.

CHICAGO

EVANSTON
DES MOINES
HIGHLAND PARK
MASON CITY
MUSKEGON
OAK PARK
MILWAUKEE
SIOUX CITY
AURORA
MINNEAPOLIS

TRIFOCALS

We are presenting two cases this month because these two cases illustrate the importance of correctly selecting, from the many trifocals on the market, the one best suited to the individual case.

The first case is Mr. D, a druggist, who required a very small distance correction and a +2.50 add for near. Mr. D's complaint was that while both the distance and the near visions were satisfactory he could not see merchandise which was above eye level and on shelves, or read the labels on prescription bottles which were similarly located. Mr. D's problem was solved by giving him "baseball" trifocals (see figure 1).

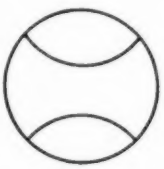


Fig. 1

In the "baseball" trifocal, the bottom segment is for reading, the central portion for distance and the upper segment is the intermediate. In the case of Mr. D the intermediate add was +1.25. The "baseball" trifocal is used for storekeepers, mail clerks, librarians and all others who need an above eye level intermediate segment.

The second case is Mr. W, an architect, whose trouble was blueprint reading. He complained that to see the far edges of a blueprint he had to either back away and use the distance lens or get closer and use the reading lens, both of which methods were most annoying and unsatisfactory. Mr. W's problem was solved by giving him ultex trifocals (see figure 2).

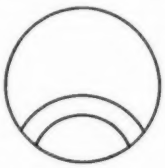


Fig. 2

The ultex trifocal has the lower portion for reading, the central portion for intermediate and the upper for distance. The ultex trifocal is excellent for use at a desk, for draftsmen, and for other occupations that require below eye level intermediate vision.

The two cases above illustrate the use of but two of the many trifocals available. It is well to know about all of them because the success of the fitting depends on the proper selection of the segment size and position. Drawings of different trifocals together with data on segment sizes and shapes will be sent you on request.

"IF IT'S A LENS PROBLEM, LET'S LOOK AT IT TOGETHER"

CONTENTS

Original Articles

PAGE

Distribution of Substrate-Specific Alkaline Phosphatases in the Ocular Tissues
Ruth A. Allen and Jonas S. Friedenwald, M.D., Baltimore 671

Flicker Sickness
George A. Ulett, M.D., Ph.D., St. Louis 685

Nature of the Corneal "Canals" Produced by Perilimbal Injections of Hydrogen Peroxide
Benjamin Friedman, M.D., New York 688

Evaluation of Wounds of the Rabbit Cornea Treated with Calsulfhydryl (Hydrosulphosol)
Robert E. Rocknem, M.D., Minneapolis 696

Visual Field Changes in Optic Neuritis
Max Chamlin, M.D., New York 699

Reconstruction of the Orbit with Polyvinyl Sponge
John W. Henderson, M.D., Rochester, Minn. 714

Optic Neuropathy in Multiple Sclerosis
Samuel Gartner, M.D., New York 718

Effects of Beta Irradiation on the Rabbit Lens
Ludwig von Sallmann, M.D.; Carmen M. Munoz, A.B., and Anne Drungis, A.B., New York 727

Comparative Features of Plastic and/or Glass in Artificial-Eye Construction
Stanley F. Erpf, D.D.S., M.S., San Francisco 737

Clinical Notes, New Instruments and Techniques

Transportation of Normal Human Eyes
James G. Fowler, M.D., Buffalo 745

Ophthalmological Reviews

Ultraviolet Radiation and Vision
John C. Ogilvie, B.Sc., M.A., Toronto, Canada 748

Annual Reviews

Glaucoma
Joseph S. Haas, M.D., Chicago 764

(Continued on Next Page)

CONTENTS—Continued

Correspondence

Monocular Aphakia PAGE

Everett L. Goar, M.D., Houston, Texas 779

Alfred Cowan, M.D., Philadelphia 779

Lens Refraction Tree

Werner Bab, M.D., San Francisco 780

Society Transactions

Canadian Ophthalmological Society 781

New York Academy of Medicine, Section of Ophthalmology 782

Regular Departments

News and Comment 788

Books 791

THE A. M. A. ARCHIVES OF OPHTHALMOLOGY is published by the American Medical Association to continue the *Archives of Ophthalmology*, founded by Herman Knapp in 1869, and to provide American ophthalmologists with a publication devoted not only to original contributions in the field of ophthalmology but to a survey of the ophthalmologic literature and a review of the transactions of ophthalmologic societies.

Communications regarding subscriptions, reprints, etc., should be addressed, A. M. A. ARCHIVES OF OPHTHALMOLOGY, American Medical Association, 535 North Dearborn Street, Chicago 10.

Manuscripts for publication, books for review and correspondence relating to the editorial management should be sent to Dr. Francis Heed Adler, Chief Editor, 313 South Seventeenth Street, Philadelphia 3.

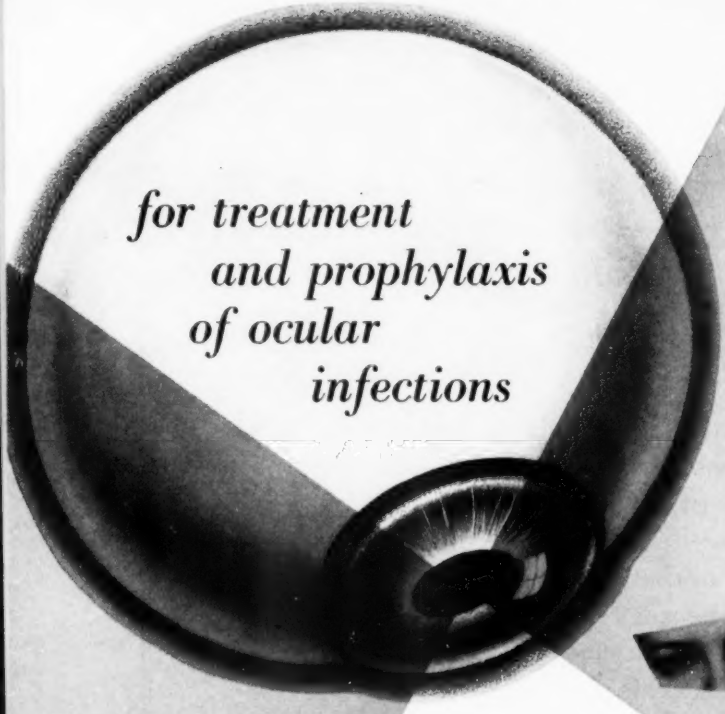
Articles are accepted for publication on condition that they are contributed solely to the A. M. A. ARCHIVES OF OPHTHALMOLOGY. Manuscripts must be typewritten, preferably double spaced, and the original copy should be submitted. Zinc etchings and halftones will be supplied by the Association when the original illustrations warrant reproduction and when their number is not considered excessive.

Footnotes and bibliographies (the latter are used only in exhaustive reviews of the literature) should conform to the style of the *Quarterly Cumulative Index Medicus*, published by the American Medical Association. This requires, in order given: name of author, title of article and name of periodical, with volume, page, month—day of month if the journal appears weekly—and year.

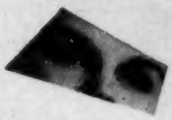
Matter appearing in the A. M. A. ARCHIVES OF OPHTHALMOLOGY is covered by copyright, but as a rule no objection will be made to its reproduction in a reputable medical journal if proper credit is given. However, the reproduction for commercial purposes of articles appearing in the A. M. A. ARCHIVES OF OPHTHALMOLOGY or in any of the other publications issued by the Association will not be permitted.

The A. M. A. ARCHIVES OF OPHTHALMOLOGY is issued monthly. The annual subscription price (for two volumes) is as follows: domestic, $12.00; Canadian, $12.40; foreign, $13.00 including postage. Current single copies are $1.25, postpaid.

Checks, money orders and drafts should be made payable to the American Medical Association.



for treatment and prophylaxis of ocular infections



Sodium

SULAMYD

Ophthalmic Solution 30%

(sodium sulfacetamide)

Sodium SULAMYD® Ophthalmic Solution 30% applied as eye drops offers *all* these advantages:

- Effective against both gram-positive and gram-negative bacteria.
- Deep penetration into intraocular tissues on conjunctival application.
- Higher local concentration of drug than obtainable with sulfonamide preparations by oral administration.
- Notable freedom from irritation — virtually non-sensitizing.

For routine daytime use: Sodium SULAMYD Ophthalmic Solution 30% — applied by eye dropper, 3 or 4 drops daily.

For bacteriostasis through the night: SODIUM SULAMYD Ophthalmic Ointment 10% before retiring.

Schering CORPORATION • BLOOMFIELD, N. J.

SCHERING

Sodium SULAMYD Ophthalmic Solution 30%

The Purpose of the Guild

- The aim of the Guild of Prescription Opticians of America is to advance the science of ophthalmic optics through the development of a country-wide ethical optical dispensing service that comprehensively meets the needs of the Eye Physicians and their patients; and to educate the public to the fact that the Eye Physician-Guild Optician type of eye service truly renders the most desirable form of eye care.

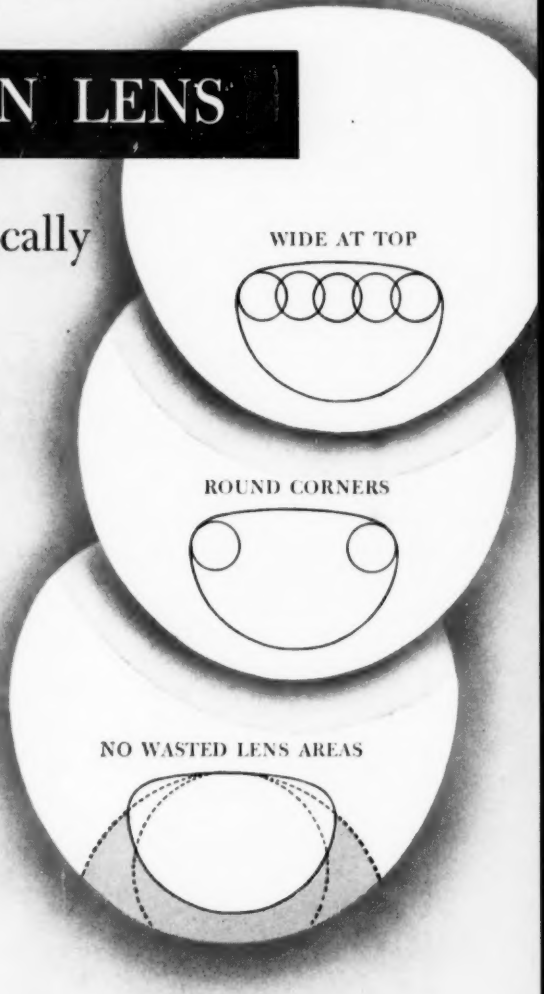
This statement of the Guild's purpose is reprinted from the cover of the REFERENCE LIST OF GUILD OPTICIANS, a geographical index of all our members. If you would like a copy, just drop a penny post card to

The Guild of Prescription Opticians of America, Inc.
110 E. 23rd Street New York (10) N.Y.

THE BAUSCH & LOMB PANOPTIK BIFOCAL IS THE

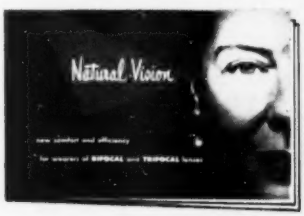
NATURAL VISION LENS

. . . with segment scientifically shaped to afford *Natural Vision* and comfort in reading . . .



The unique construction principle on which Panoptik is based permitted designers to call for *any* desired segment shape. The shape selected was the result of exhaustive tests and measurements undertaken to establish exact segment size and shape most ideally suited to natural reading habits. The Panoptik segment is *wide* at the top, to provide a wide reading field, *at the eye level naturally used for reading*. It has round corners to match the round pupil of the human eye. It wastes none of the lens in "blind" or unused areas.

in Soft-Lite, too



A new Bausch & Lomb booklet, "Natural Vision," tells what patients want in a bifocal lens, describes the characteristics which result in Panoptik's superior performance among bifocals, trifocals and special purpose multifocals. Ask your Bausch & Lomb distributor's representative.

BAUSCH & LOMB

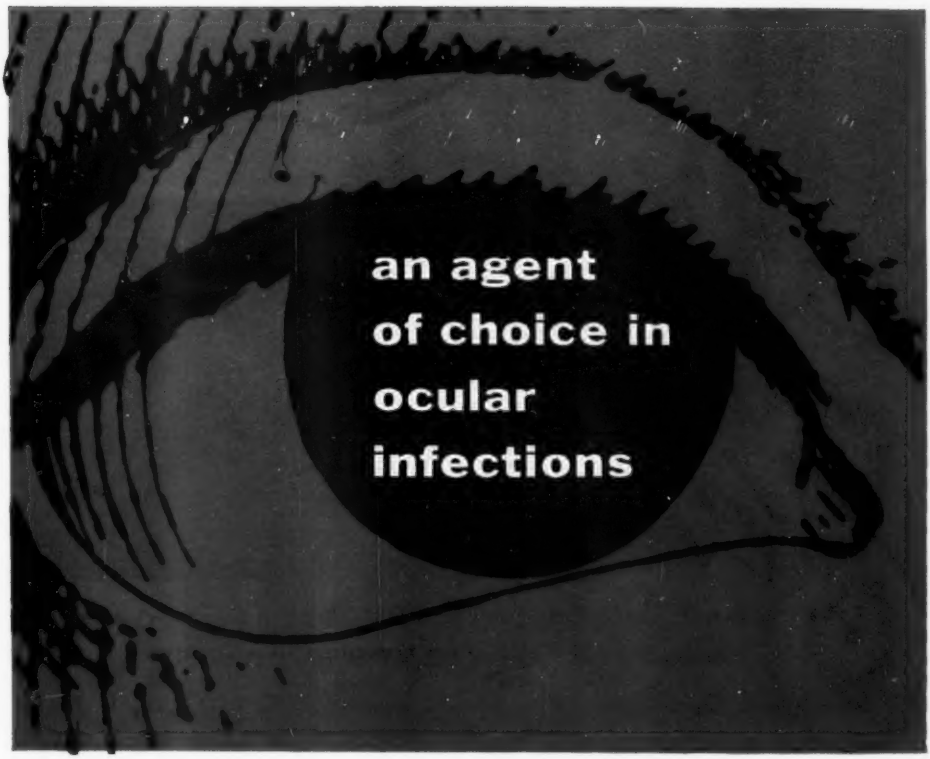
OPTICAL COMPANY ROCHESTER 2, N.Y.

1853 1953 INTO A NEW CENTURY OF OPTICAL PROGRESS
BAUSCH & LOMB CENTENNIAL

Peace on Earth
Good Will Toward Men

The privilege of sharing
The joy of giving
The greeting of friends
The freedom of worship
The merry laughter of children
The sumptuous Christmas dinner
The fragrance of cut spruce
The sparkle of decorations
The family and the fireside;
This is our Christmas . . .
may it be yours!

Titmus Optical Company, Inc.



Terramycin®

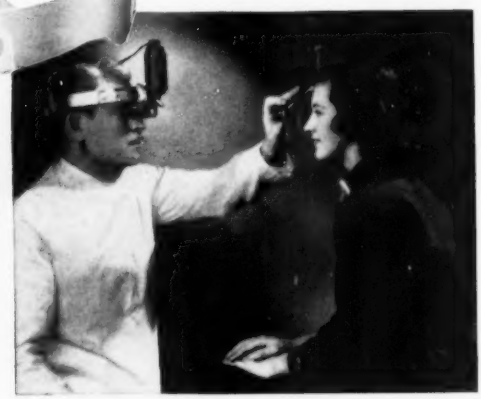
BRAND OF OXYTETRACYCLINE

The wide range of causative organisms sensitive to well-tolerated Terramycin makes this promptly effective, broad-spectrum antibiotic an agent of choice in the treatment of many common ocular infections including conjunctivitis, blepharitis, trachoma, scleritis, keratitis, iritis, dacryocystitis, corneal ulcers. Terramycin is supplied in convenient preparations for both topical use and for systemic therapy.

TERRAMYCIN – in convenient dosage forms for the treatment of ocular infections.

Pfizer

PFIZER LABORATORIES, *Brooklyn 6, N. Y.*
DIVISION, CHAS. PFIZER & CO., INC.



New!

THE ONLY SELF-LUMINOUS STEREOSCOPIC *INDIRECT* OPHTHALMOSCOPE

AO-SCHEPENS BINOCULAR INDIRECT OPHTHALMOSCOPE OFFERS MANY PRACTICAL ADVANTAGES

- **OBSERVATION TO THE EXTREME FUNDUS PERIPHERY**
- **GREATER FIELD OF VIEW**
- **RELATIVELY LOW MAGNIFICATION**
- **STEREOSCOPIC IMAGE**
- **MORE POWERFUL ILLUMINATION**
- **COMFORTABLE WORKING DISTANCE**

The new lightweight AO-Schepens Binocular Ophthalmoscope allows you to study details of the fundus to the extreme periphery. With the aid of scleral depression technique proficient observers can examine the ora serrata and the posterior portions of the pars plana ciliaris. The instrument is particularly useful in examining retinal detachments, tumors, retrolental fibroplasia, perforating wounds, and other pathological conditions practically impossible to examine adequately by other means in the region anterior to the equator. In this and the posterior regions wide field and low magnification provide an excellent means of observing the general fundus topography . . . while the three-dimensional image and exceptional depth of focus clarify details of irregular depth.

A powerful illuminating unit is combined with the observation system on a comfortable headband giving adequate support and adjustability. Interpupillary distance is adjustable. Three coated condensing lenses are supplied — a small diameter + 20D lens for the operating room, a medium diameter + 20D lens for routine examination, and a large diameter + 14D lens for examining minute fundus details.

Ask your AO Representative or supplier for literature and a demonstration.

American Optical

INSTRUMENT DIVISION

Major advance in dermatitis control:

The new direct approach to the control of dermatitides is hormonal, enlisting the antiphlogistic and antiallergic potency of compound F—foremost of the corticosteroid hormones.

The new objective is adapting corticoid therapy to simple inunction treatment, and obtaining relief in various forms of dermatitides within days—sometimes within hours.

The new attainment is Cortef Acetate Ointment, which rapidly controls edema and erythema, halts cellular infiltration, arrests pruritus in such harassing skin problems as atopic dermatitis, contact dermatitis, lichenified pruritus vulvae and ani, neurodermatitis, and seborrheic dermatitis.

Cortef*

Acetate Ointment

Supplied: *Cortef Acetate Ointment is available in 5 Gm. tubes in two strengths—2.5% concentration (25 mg. per Gm.) for initial therapy in more serious cases of dermatitis, and 1.0% concentration (10 mg. per Gm.) for milder cases and for maintenance therapy.*

Administered: *A small amount is rubbed gently into the involved area one to three times a day until definite evidence of improvement is observed. The frequency of application may then be reduced to once a day or less, depending upon the results obtained.*

*TRADEMARK FOR UPJOHN'S BRAND OF HYDROCORTISONE

A product of Upjohn Research *for medicine...produced with care...designed for health*

THE UPJOHN COMPANY, KALAMAZOO, MICHIGAN

CHICAGO OPHTHALMOLOGICAL SOCIETY

1954 CLINICAL CONFERENCE

February 5 and 6, The Drake Hotel

Symposia and Round Table Luncheons

Headache
Surgery of the Lids

Lectures

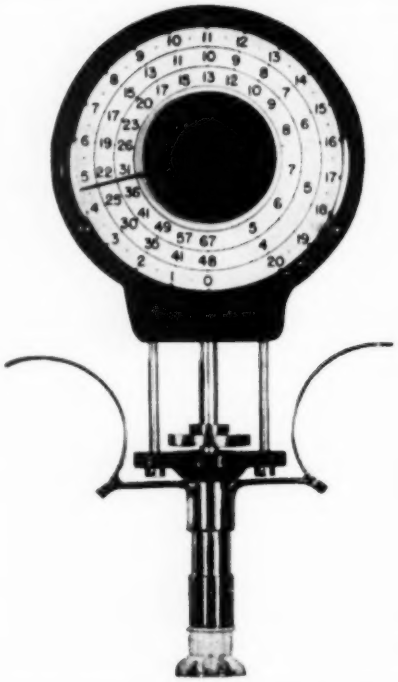
Technic and Results of the Recession Operation for Squint
Lens Metabolism
Dacryocystorhinostomy
Vertical Divergence of the Eyes and the Use of Prisms
On the Basis of Stereopsis in Binocular Vision

Participants:

Percival Bailey, Chicago
Benjamin Boshes, Chicago
Alston Callahan, Birmingham, Ala.
Fremont Chandler, Chicago
Charles E. Iliff, Baltimore, Md.
Robert W. Keeton, Chicago
Francis L. Lederer, Chicago
Placidus Leinfelder, Iowa City
Kenneth Ogle, Rochester, Minn.
Kenneth Swan, Portland, Oregon

Fee $35.00 (Round table luncheons included)
Registrar: Miss Maud Fairbairn, 8 West Oak Street, Chicago 10, Ill.

THE TENTH ANNUAL GIFFORD MEMORIAL LECTURE
Dr. Kenneth Swan, Portland, Oregon: "The Blind Spot Mechanism."
5:30 P.M., February 5, 1954, The Drake Hotel.
The Chicago Ophthalmological Society cordially welcomes all ophthalmologists to attend the Gifford Memorial Lecture.



The New

HARRINGTON TONOMETER

This is an extremely accurate instrument.

The dial has three scales, the outer being the expanded Schiotz scale, 0 to 20, the middle and inner scales being direct readings in millimeters of mercury for the 5.5 and 7.5 gram weights.

10 and 15 gram weights are included, with conversion table.

Descriptive leaflet sent on request.

Fully guaranteed

PARSONS OPTICAL LABORATORIES

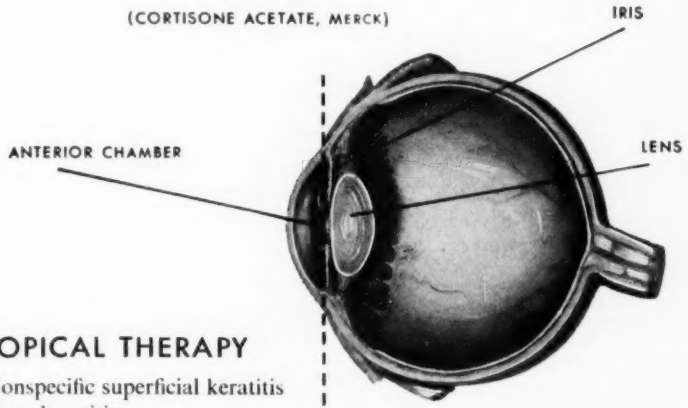
518 Powell Street San Francisco 2, Calif.

"...one of the most important contributions to ophthalmologic therapy in a decade..."[1]

Cortone®

ACETATE

(CORTISONE ACETATE, MERCK)



TOPICAL THERAPY

Nonspecific superficial keratitis
Deep keratitis
Acne rosacea keratitis
Ophthalmic herpes zoster
Sclerokeratitis
Phlyctenular keratoconjunctivitis
Allergic conjunctivitis
Vernal conjunctivitis
Chronic conjunctivitis (antibiotics also may be required)
Acute iritis
Chronic iritis
Recurrent marginal ulceration

SYSTEMIC THERAPY

Iritis and iridocyclitis
Chorioretinitis
Nonspecific choroiditis
Nonspecific uveitis
Retinitis centralis
Ophthalmic herpes zoster
Optic neuritis, including retrobulbar neuritis
Sympathetic ophthalmia
Uveitis following surgery

1. Fine, M., and Goodwin, R. C.: *A.M.A. Arch. Ophth.* 47:787-797, June 1952.

CORTONE is the registered trade-mark of Merck & Co., Inc. for its brand of cortisone.

MERCK & CO., INC.
Manufacturing Chemists
RAHWAY, NEW JERSEY

© Merck & Co., Inc.

Rx

QUALITY SERVICE

Technical skills and services that will never let you down

DOW

Top-Grade Technical Performance

. . . a Safeguard for Your Professional Skills and Judgment

¶Your prescriptions, conceived from your rich fund of scientific knowledge laboriously developed through years of study, training and experience, are at the mercy of the dispensers who interpret them. They will be safe in the hands of Dow seasoned craftsmen, whose devotion to the exacting standards which your professional reputation demands, and which our firm has consistently maintained throughout its 31 years of existence, is a guarantee of complete patient satisfaction.

DOW OPTICAL CO.

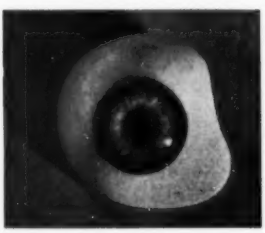
W. E. DOW, Pres.

Chicago, Ill. Bloomington, Ill.

Specialists in ALL TYPES of Plastic and Glass Artificial Human Eyes Exclusively

MADE TO ORDER IN OUR OWN LABORATORY

Doctors are invited to visit



REFERRED CASES CAREFULLY ATTENDED AND SATISFACTION GUARANTEED

EYES ALSO FITTED FROM STOCK

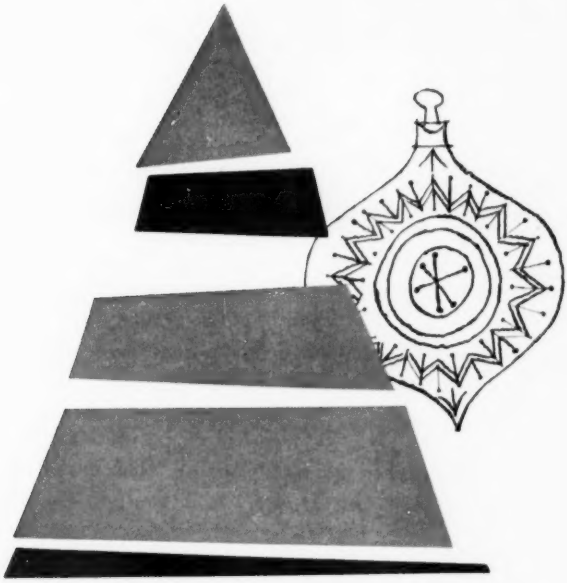
Plastic or Glass Selections Sent on Memorandum upon Request

Implants and Plastic Conformers in Stock

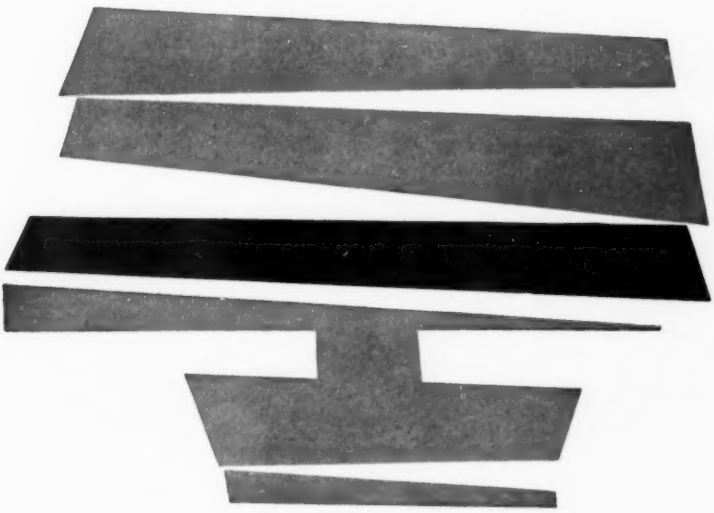
FRIED AND KOHLER, INC.

665 FIFTH AVENUE
near 53rd St.

NEW YORK, N. Y.
Tel. ELdorado 5-1970



SEASON'S BEST



CONTINENTAL - INDIANAPOLIS

WHEN DRUG IRRITATION IS A FACTOR . . .

OPHTHALMOS

PILOCARPINE HCl.
Solutions 1% and 2%

OFFER COMFORT AND CONTINUITY OF THERAPY IN THE TREATMENT OF THE *Glaucomas*

—UNDESIRABLE SIDE EFFECTS VIRTUALLY ELIMINATED—
RAPID PROLONGED ACTION

OPHTHALMOS

Sterile Pilocarpine HCl. Solutions in Dropper Sealed Bottles Originated by Robert R. Feinstein Research Associates

Available at Prescription Pharmacies throughout the U.S.A. and Canada or write

LITERATURE ON REQUEST

OPHTHALMOS, INC.
4808 BERGENLINE AVE.
UNION CITY, N.J.

SHURON

all for the *best* and the best for *all*

SHURON OPTICAL COMPANY INC. • GENEVA, N. Y.

Doctor, would it be helpful to you in your practice to know that there is a food available at reasonable prices in the stores the year round having these attributes:

1. High public acceptance as to flavor and palatability—billions eaten annually.

2. One of the best of the "protective" foods with a well-rounded supply of vitamins and minerals.

3. Low sodium—very little fat—no cholesterol.

4. Sealed by nature in a dust-proof package.

5. One of the first solid foods fed babies.

6. Can be easily digested by old folks as well as infants.

7. Can be readily eaten out of hand, in milk shakes, on cereals, or in salads.

8. Can be baked, broiled or fried.

9. Can be used as an ingredient product in breads, pies, cakes and desserts.

10. Useful in bland and low-residue diets.

11. Mildly laxative.

12. May be used in the management of both diarrhea and constipation.

13. Can be used in reducing diets.

14. Can be used in high-calorie diets.

15. Useful in the dietary management of celiac disease.

16. Useful in the dietary management of idiopathic non-tropical sprue.

17. Useful in the management of diabetic diets.

18. Valuable in many allergy diets.

19. Belongs among foods useful in certain acute intestinal infections.

20. A protein sparer.

21. Favorably influences mineral retention.

22. Useful in the management of ulcer diets.

23. One of the easiest foods to eat or prepare.

FOR THE NAME OF THIS FOOD, PLEASE TURN THE PAGE

The answer is

B A N A N A S

If you would like

1. The authority for any of the statements made on the preceding page . . .
2. Additional information in connection with any of them...
3. The composition of the banana . . .
4. The nutritional story of the banana . . .
5. Information on various ways to prepare or serve bananas.

Please feel free to write to

Director, Chemical and Nutrition Research, United Fruit Company

PIER 3, NORTH RIVER, NEW YORK 6, N. Y.

E. B. Meyrowitz

SURGICAL INSTRUMENTS CO., INC.,
520 FIFTH AVENUE, NEW YORK 36, N. Y.

LONDON *ESTABLISHED 1875* **PARIS**

SCHWEIGGER HAND PERIMETER

This is a portable instrument adapted for plotting perimetric fields or for measurement of monocular rotation by the corneal reflex or Purkinje image method.

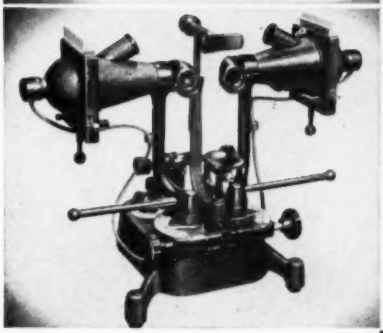
The instrument is held by the patient with a plate against the inferior margin of the orbit to fix the position of the arc before the eye. The arc has a radius of 17 cm. and covers a field of 180 degrees. It may be rotated to any desired angle and a graduated disc indicates the angle in use. The arc is marked in degrees.

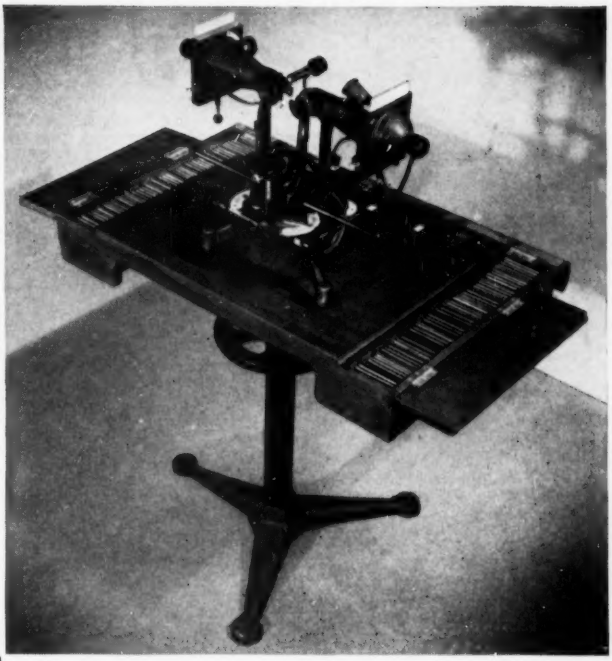
The perimeter folds flat so that it is easily portable but is sufficiently sturdy for routine examinations in the office. It is nicely finished in gray and is supplied complete with test objects, a wand and record charts. **Price $36.50**

HERTEL EXOPHTHALMOMETER

Improved over the original German model, in that it has front surface mirrors which do away with parallax, this exophthalmometer enables the examiner to measure the degree of exophthalmia accurately and rapidly without assistance.

The right member slides over a calibrated millimeter rule. Each member has two mirrors mounted at right angles, one above the other. When the instrument is in position, with the two outer points in contact with the temporal margin of each orbit, the profile of the cornea is seen in one mirror and the scale in the other. The scale reading directly above the corneal image gives its protrusion in millimeters.
The separation of the two members is shown on the slide. All measurements of the same case must be made with the members separated to the same reading on the sliding scale.
Supplied in case. **Price $55.00**





THE MOORFIELDS SYNOPTOPHORE

from

CLEMENT CLARKE

of

England

The Moorfields Synoptophore has long enjoyed the universal recognition as a most important orthoptic apparatus. Originally evolved from the simple Worth's Amblyoscope, its development has kept pace with the many improvements in orthoptic technique.

When the two optical tubes are moved through any angle the movements are concentric with those of the visual axes. A simple slow motion device is provided for duction exercises, and by releasing a locking key the two tubes may be rotated in co-ordination for kinetic exercises.

Large diameter lenses and stainless steel mirrors, producing a brilliant image, are fitted into eyepieces so shaped to facilitate observation of the corneal reflexes. Auxiliary cells for standard sized trial lenses and prisms are supplied.

The interlenticular distance may be varied from 50 mm. to 80 mm. Interpupillary distances smaller than 50 mm. are perfectly accommodated. Cyclophoria and hyperphoria may be measured with great accuracy and the slow motion vertical screw is also valuable in estimating vertical ductions. Other features include adjustable chin and forehead rests, two flashing switches of the latest micro type and two dimming rheostats.

CLEMENT CLARKE ORTHOPTIC EQUIPMENT INCLUDES:
The Lyle Major Amblyoscope, Hess Screens, Cheiroscopes, Worth's 4 Dot Tes , Diplopia Goggles, Rotating E Test, Maddox Handframe, Maddox Wing Test, Bar Readers, etc.

CLEMENT CLARKE of ENGLAND

GUILD OPTICIANS

63, WIGMORE STREET, LONDON, W.1. ENGLAND

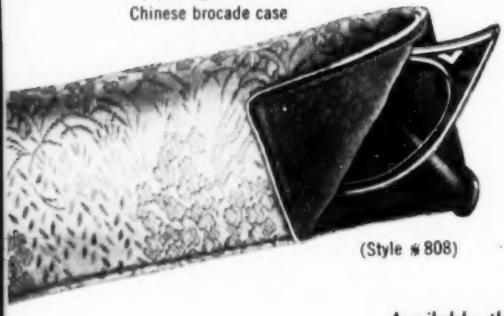
Sole Agents in U.S.A.

CURRY & PAXTON INC., ( ) 101, PARK AVENUE, N.Y. 17. LEXINGTON 2-7842

Tang by VICTORY

. . . mirror of fashion

Tang comes to you individually packaged in a rich Chinese brocade case



(Style # 808)

Because it truly reflects the fashion needs of today's woman . . . because it embodies today's trend to sophisticated glamour styling . . . Tang is on the way to becoming America's most wanted frame. In striking colors and combinations, with beautifully designed trim of 1/10 12K gold filled.

Colors: Slate Blue, Black, Brandy, Bronze, Slate Blue on Crystal, Black on Crystal, Brandy on Crystal, Bronze on Crystal.

Available through your Optical Supplier

Victory Optical
MANUFACTURING COMPANY
NEWARK, N. J. · CHICAGO · LOS ANGELES · ATLANTA

A. M. A.
ARCHIVES OF OPHTHALMOLOGY

VOLUME 50 DECEMBER 1953 NUMBER 6

COPYRIGHT, 1953, BY THE AMERICAN MEDICAL ASSOCIATION

DISTRIBUTION OF SUBSTRATE-SPECIFIC ALKALINE PHOSPHATASES IN THE OCULAR TISSUES

RUTH A. ALLEN
AND
JONAS S. FRIEDENWALD, M.D.
BALTIMORE

PREVIOUS work from this laboratory (Maengwyn-Davies, Friedenwald, and White [1]) has shown that it is possible to demonstrate histochemically in fresh frozen tissue a group of substrate-specific enzymes which hydrolyze various phosphate esters in an alkaline environment. The methods devised give information as to the identity of the enzymes which are tested and also as to their location in the tissues. In the present study these methods have been applied to the ocular tissues. The fact that different tissues in a structure as highly organized as the eye have different complements of enzymes is hardly surprising. No doubt the variety of enzyme composition in different cells is an expression of their varied metabolic activities and of the metabolic interactions which contribute to organ functions.

Maengwyn-Davies found that in an alkaline environment two enzyme systems attack the polyglycol monophosphate esters glycerophosphate, glucose-1-phosphate, glucose-6-phosphate, and fructose-6-phosphate. The A system, which is active in the absence of magnesium, is substrate-specific, while the B system, which requires activation by magnesium, appears to attack all four of these substrates. Two enzymes were differentiated for creatine phosphate, one active at pH 9.9 and not requiring magnesium, the other active at pH 9.0 in the presence of magnesium. It was also shown that adenosinetriphosphate is attacked by at least two different enzymes, one at pH 9.9 and the other at pH 8.25. Neither of these enzymes is identical with myosin adenosinetriphosphatase, and either or both may be nonspecific pyrophosphatases. In addition, several other substrate-specific alkaline phosphatases were demonstrated. The localization in the ocular tisues of these enzymes is the purpose of the present study.

From the Wilmer Ophthalmological Institute, The Johns Hopkins University and Hospital.
This work has been supported by a grant from the National Cancer Institute.

1. (*a*) Maengwyn-Davies, G. D., and Friedenwald, J. S.: Histochemical Studies of Alkaline Phosphatases in the Tissues of the Rat Using Frozen Sections: I. Substrate Specificity of Enzymes Hydrolyzing Poly-Glycol-Mono-Phosphate Esters, Hexose-Diphosphate, and β-Naphthylphosphate, J. Cell. & Comp. Physiol. **36**:421, 1950. (*b*) Maengwyn-Davies, G. D.; Friedenwald, J. S., and White, R. T.: Histochemical Studies of Alkaline Phosphatases in the Tissues of the Rat Using Frozen Sections: II. Substrate Specificity of Enzymes Hydrolyzing Adenosine-Triphosphate, Muscle- and Yeast-Adenylic Acids, and Creatine-Phosphate at High PH; the Histochemical Demonstration of Myosin ATP-Ase, ibid. **39**:395, 1952.

MATERIALS AND METHODS

Enucleations were performed on albino rabbits under pentobarbital sodium anesthesia. The eye was bisected equatorially and as much vitreous as possible removed. The tissue to be sectioned was immediately mounted in saline on the stage of a freezing microtome and 15 to 20 μ sections cut, using the technique of White and Allen.[2]

The general principles of the enzyme-localizing technique consist in incubating the tissue sections in a solution containing the test substrate (an organic phosphate ester) in the presence of excess calcium ions. If the test substrate is hydrolyzed by an enzyme present in the tissue, inorganic phosphate will be liberated and calcium phosphate will be precipitated in the section at or near the site of the enzyme activity. When the incubation has been terminated, the calcium phosphate is converted by a series of steps into cobalt sulfide, yielding a black granule. The abundance and distribution of such granules furnish an index of the activity and location of the enzyme tested.

The incubation mixtures employed were those described by Maengwyn-Davies and associates [1] for the following substrates: glycerophosphate, glucose-1-phosphate, glucose-6-phosphate, fructose-6-phosphate, fructose-1,6-diphosphate, β-naphthylphosphate, creatine phosphate, adenosine-3-phosphate, adenosine-5-phosphate, and adenosinetriphosphate. A sharper pattern of localization for the enzyme attacking fructose-1,6-diphosphate was achieved by the addition of magnesium and boiled kidney extract to the incubation mixture in accordance with the findings of Maengwyn-Davies and Friedenwald.[1a] In instances in which no activity was found for β-naphthylphosphate at 5 C., the experiment was repeated at 37 C. Control sections were prepared by incubating the tissue in solutions in which the substrate solution had been replaced by water.

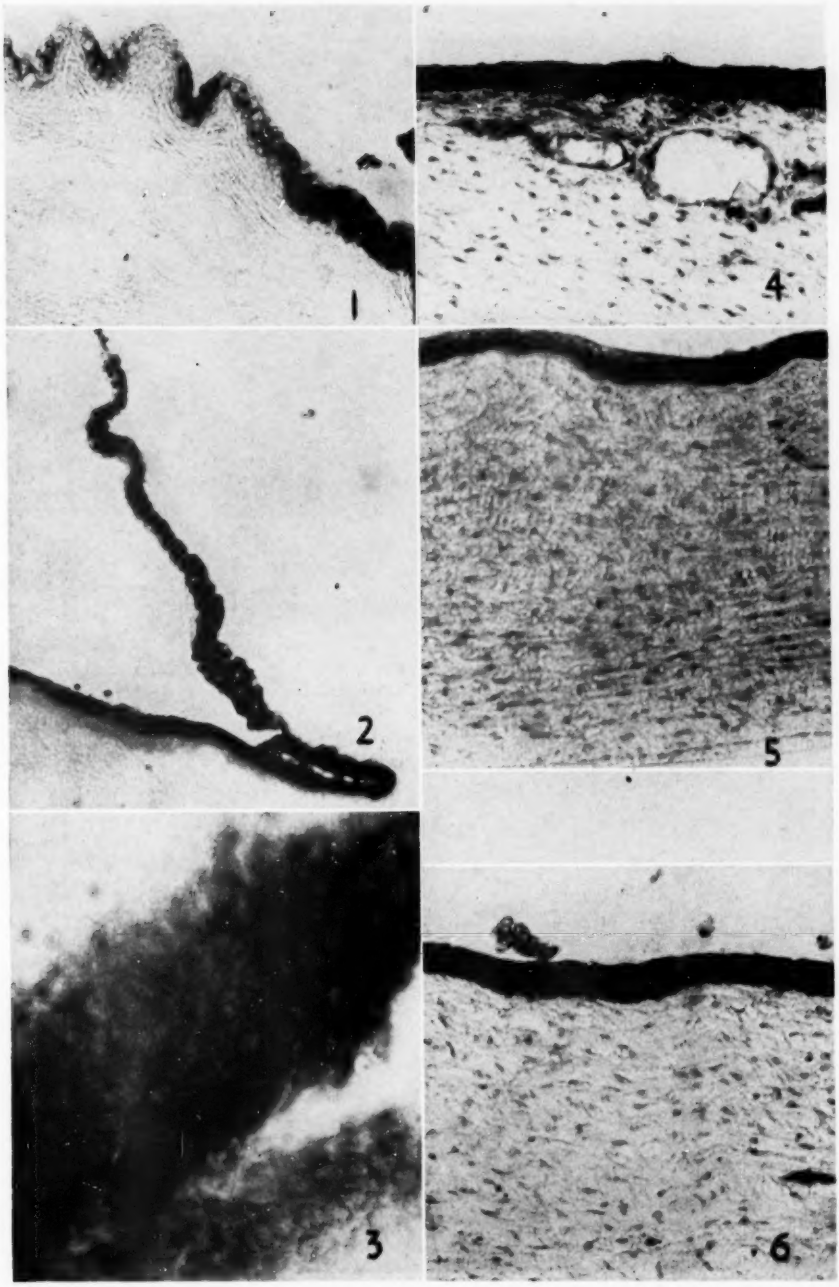
At the end of the desired incubation time the sections were washed with a 1:1 solution of absolute alcohol and 4% $CaCl_2$. Staining and mounting procedures followed those described by Maengwyn-Davies and Friedenwald.[1a]

RESULTS

A survey of the histological findings follows.

Lens.—No activity of the enzymes attacking the polyglycol monophosphate substrates, β-naphthylphosphate, creatine phosphate, adenosine-3-phosphate, or adenosine-5-phosphate was found. After five hours' incubation, fructose-1,6-diphosphate was dephosphorylated in the epithelium beneath the lens capsule, the nuclei of the lens bow, and the cell membranes of the lens fibers. The intensity of the stain in the fiber surfaces was greatest near the capsule and faded out in the deeper cortex. In all sections, including controls without substrate, the nucleus of the lens was diffusely dark. This artifactual staining of the lens nucleus could be avoided by incubation with a glycine buffer in the absence of acetate and of substrate, producing a completely negative control. After 16 hours' incubation with fructose-1,6-diphosphate in a similar incubation mixture, the cortex showed a normal staining intensity, but the stain was less crisply localized in the cell surfaces than when a half-saturated acetate was used in the substrate solution. The lens nucleus in the absence of acetate shows only an irregular and patchy stain. It is concluded that the staining of the lens nucleus was an artifact, not attributable to enzyme activity. Several sections were counterstained with eosin after incubation with fructose-1,6-diphosphate; the cytoplasm of the lens cells took a normal stain, indicating that the localization of enzyme activity in the cell surfaces was not due to the loss of cell cytoplasm. With adenosinetriphosphate at pH 9.9 after 40 hours' incubation and at pH 8.25 after 23 hours'

2. White, R. T., and Allen, R. A.: An Improved Clinical Method for Sectioning Frozen Tissue, Stain Technol. **26**:137, 1951.



Figs. 1-6.—*1*, glycerophosphate + magnesium; 18 hours. Phosphatase activity in conjunctival epithelium. Note absence of activity in cell nuclei and in mucin droplets. × 100.

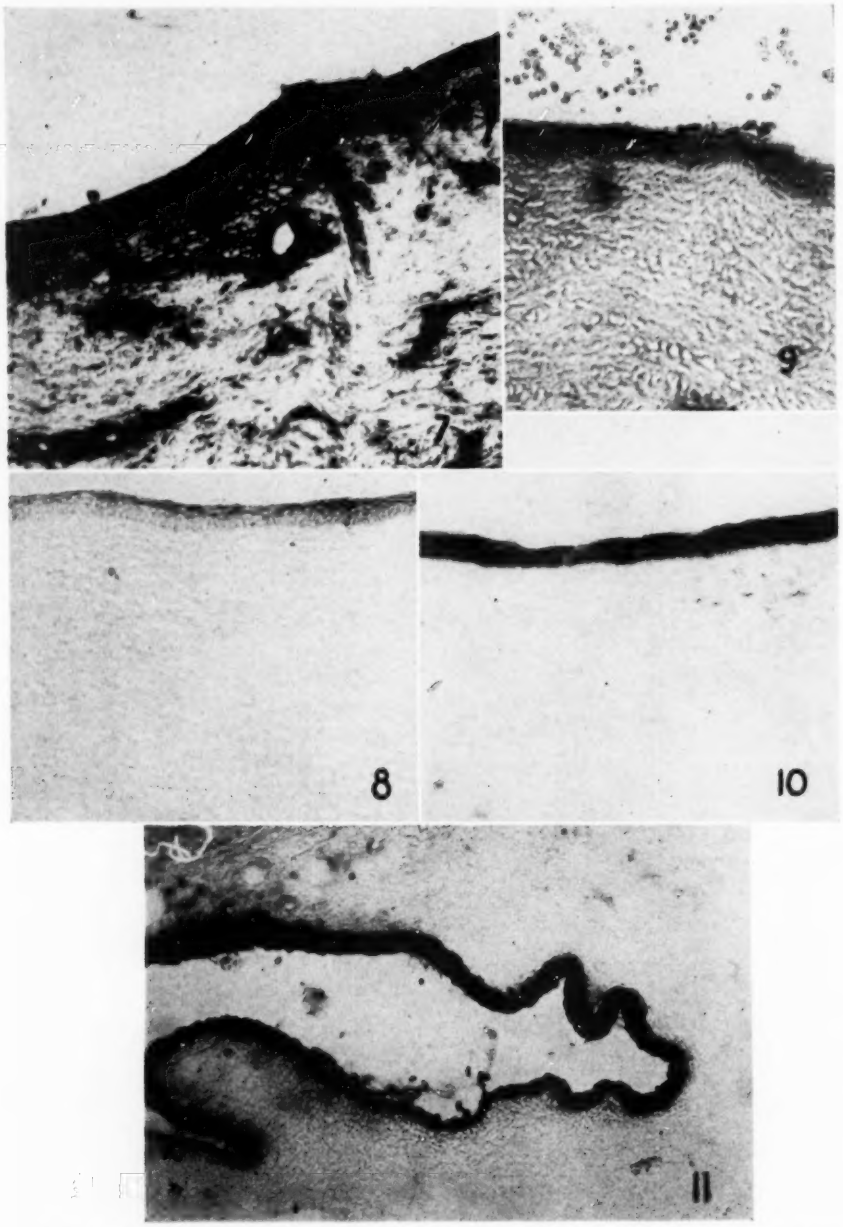
2, β-naphthylphosphate; 37 C.; four hours. Activity in corneal and conjunctival epithelium. × 100.

3, β-naphthylphosphate; 37 C.; four hours. Activity in cytoplasm of corneal epithelium, not in nuclei. × 500.

4, hexose diphosphate; five hours. Conjunctiva and cornea at the limbus. Activity in epithelium, stroma cells, and vascular endothelium. × 100.

5, hexose diphosphate; five hours. Extranuclear activity in corneal epithelium and stroma cells; no activity in corneal endothelium. × 100.

6, adenosinetriphosphate; pH 8.25; 23 hours. Activity in corneal epithelium and stroma cells. × 100.



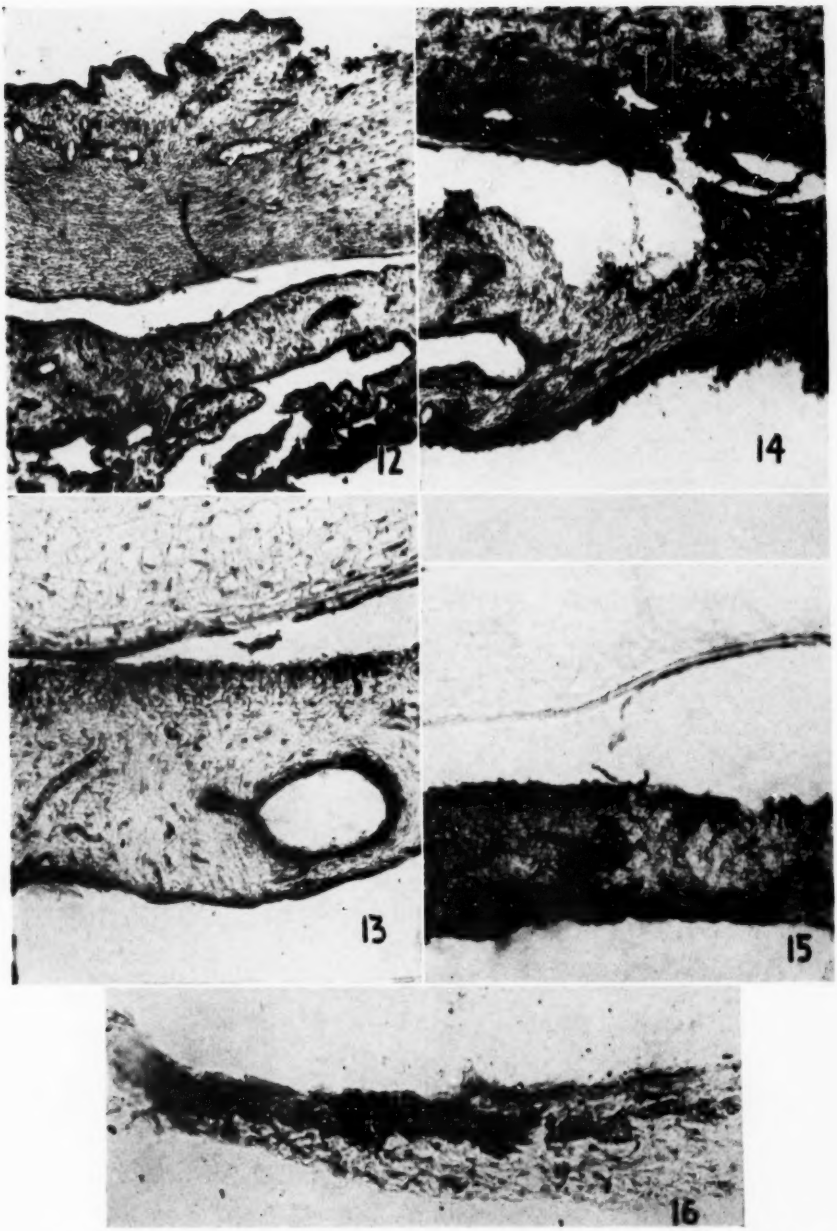
Figs. 7-11—*7*, adenosinetriphosphate; pH 9.9; 23 hours. Intense activity in walls of blood vessels, as well as in epithelium and stroma cells. × 100.

8, adenosinetriphosphate; pH 9.9; 23 hours. Cornea; × 100. This figure is to be compared with Figure *6*. At the higher pH there is no activity in the corneal stroma cells.

9, adenosine-3-phosphate; five hours. Cornea; × 100. Extranuclear activity in epithelial cells.

10, adenosine-5-phosphate; 30 hours. Cornea; × 100. Extranuclear staining of corneal epithelium; no activity in stroma cells.

11, adenosine-5-phosphate; 48 hours. Cornea and conjunctiva; × 100.



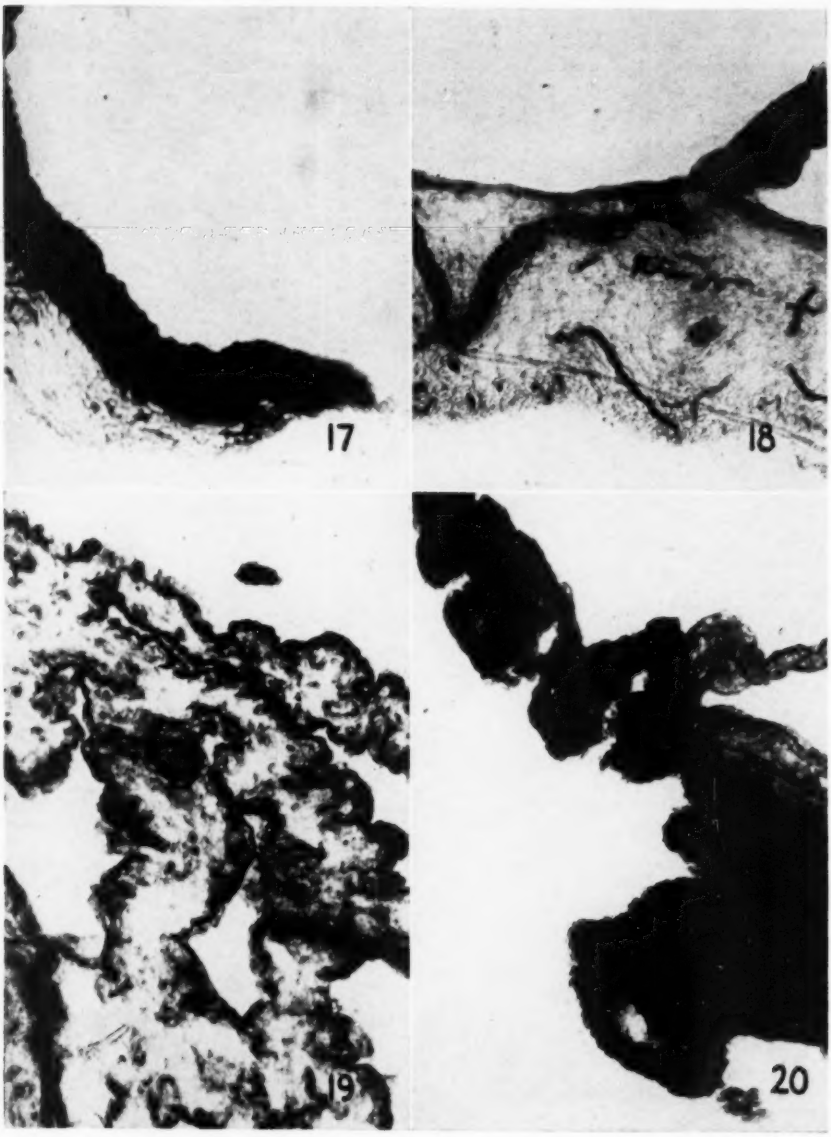
Figs. 12-16.—*12*, hexose diphosphate + Mg + boiled kidney extract; four hours. Limbal tissues, iris, and ciliary processes; × 50.

13, adenosine triphosphate; pH 8.25; 23 hours. Cornea and iris; × 100. Note activity in corneal endothelium and in blood vessels of iris.

14, adenosinetriphosphate; pH 8.25; 23 hours. Chamber angle; × 100.

15, adenosinetriphosphate; pH 9.9; 30 hours. Cornea and iris; × 100. This figure is to be compared with Figure 13. Note that at the higher pH, in spite of heavier deposits in the iris, the corneal stroma and endothelium show less activity than at the lower pH.

16, hexose diphosphate + Mg + boiled kidney extract; 18 hours. Section through iris, showing activity in the sphincter muscle; × 100.



Figs. 17-20.—*17*, adenosinetriphosphate; pH 9.9; 30 hours. Section through iris, showing heavily stained sphincter muscle; × 100.

18, adenosinetriphosphate; pH 9.9; 23 hours. Iris and ciliary process; × 100.

19, hexose diphosphate + Mg + boiled kidney extract; four hours. Ciliary processes; × 100.

20, adenosinetriphosphate; pH 9.9; 23 hours. Ciliary processes; × 100.

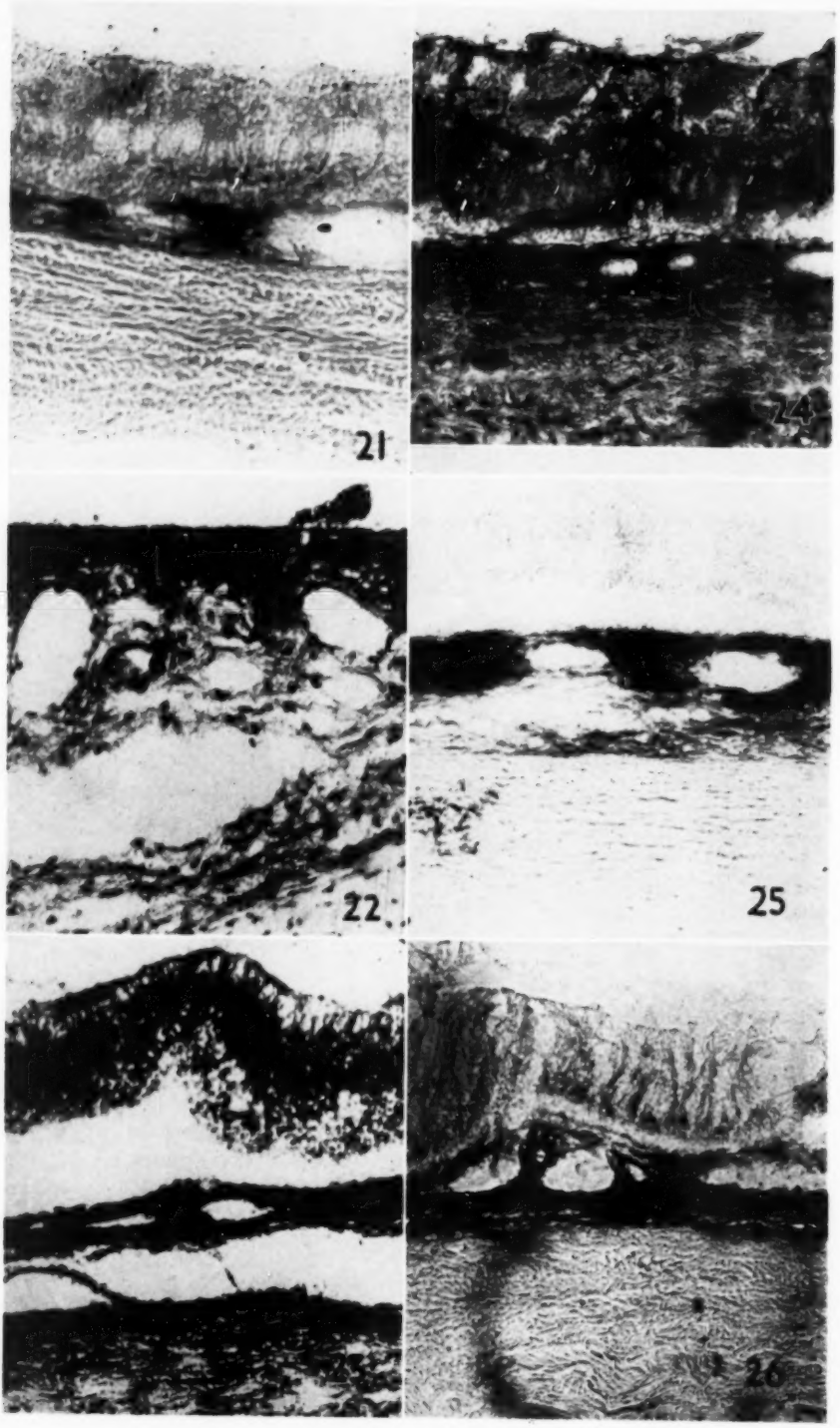
incubation, patterns developed similar to those seen with fructose-1,6-diphosphate at shorter incubations, but the activity was more diffuse in the cytoplasm of the lens fibers and less concentrated on their surface and in their nuclei.

Iris.—The polyglycol monophosphate substrates, β-naphthylphosphate, creatine phosphate, and the adenylic acids did not appear to be enzymatically hydrolyzed in the iris. With fructose-1,6-diphosphate as substrate, strong activity occurred in the epithelium, stroma cells, capillaries, blood vessels, and sphincter muscle after four hours' incubation. The surface endothelium of the iris was also active, but to a slighter degree. At 23 hours' incubation with adenosinetriphosphate at pH 9.9, the same structures showed activity. The stain was more diffuse, with the capillary endothelium showing strong activity and the iris epithelium appearing less deeply stained. Adenosinetriphosphate, pH 8.25, yielded a similar picture after 23 hours.

Ciliary Body.—No staining occurred upon incubation with any of the polyglycol monophosphate substrates in the absence of magnesium or with creatine phosphate. The epithelium of the ciliary processes showed slight activity with polyglycol monophosphate substrates in the presence of magnesium at 24 to 48 hours; β-naphthylphosphate, 5 C. at 18 hours and adenosine-3-phosphate and adenosine-5-phosphate at 22 hours. With fructose-1,6-diphosphate the epithelium was darkly stained at four hours. Cytoplasm of the stroma cells, capillaries, blood vessels, muscle cells, and scleral meshwork also showed activity. A similar pattern of staining was found with adenosinetriphosphate pH 9.9 and with adenosinetriphosphate pH 8.25, at 23 hours, the capillaries and scleral meshwork being more heavily stained.

Cornea.—No enzymatic activity was found for the polyglycol monophosphate substrates with or without magnesium, for β-naphthylphosphate, or for creatine phosphate. At four hours' incubation with fructose-1,6-diphosphate, the corneal epithelium was rather dark. The endothelium and the nuclei of the stroma cells also showed activity. With adenosinetriphosphate, pH 9.9, the epithelium was slightly stained at 23 hours. At 30 hours the epithelium was black and the endothelium slightly stained, while the stroma cells showed no activity. With adenosinetriphosphate pH 8.25 the epithelium began to stain at five hours. At 23 hours the epithelium and endothelium showed heavy deposits, as did the nuclei of the stroma cells. Adenosine-3-phosphate, at 48 hours, and adenosine-5-phosphate, at 23 hours, were slightly hydrolyzed in the corneal epithelium.

Conjunctiva.—The A enzyme system for the polyglycol monophosphate substrates appeared to be absent in the conjunctiva. On 20 hours' incubation the magnesium-activated B enzyme system, splitting all polyglycol monophosphate substrates, was demonstrable in the conjunctival epithelium. Fructose-1,6-diphosphate, after four hours' incubation, was dephosphorylated in the epithelium, stroma cell nuclei, and blood vessels. With β-naphthylphosphate at 37 C., the epithelium was active at 4 hours, while at 5 C. a similar picture occurred after 42 hours' incubation. The magnesium-activated enzyme attacking creatine phosphate at pH 9.0 and the enzyme splitting creatine phosphate at a higher pH in the absence of magnesium both appeared active in the epithelium at 24 hours. With adenosinetriphosphate at pH 9.9 as substrate, good activity was found in the epithelium, blood vessels, and stroma cells. At five hours' incubation with adenosinetriphosphate, pH 8.25, the epithelium was again very active, but stroma cells and capillaries were only slightly stained. Both adenylic acids elicited slight activity in the epithelium after 23 hours.



Figures 21-26

(See legends on opposite page)

Sclera.—No activity was found in the sclera for the A or B enzyme systems or for those enzymes attacking creatine phosphate, adenosine-3-phosphate, or adenosine-5-phosphate. After 10 hours with β-naphthylphosphate, at 37 C., a slight stain occurred in the stroma cell nuclei. Fructose-1,6-diphosphate was dephosphorylated at four hours in the stroma cells, as well as in the blood vessels and capillaries. Adenosinetriphosphate pH 9.9 gave a somewhat diffuse stain of the stroma cells at 22 hours. A similar picture was obtained with adenosinetriphosphate pH 8.25 at four hours.

Choroid.—The A enzyme system and the enzyme systems splitting creatine phosphate did not appear to be active in this tissue. The magnesium-activated B enzyme system showed activity for all polyglycol monophosphate substrates in the choroidal stroma and suprachoroid after 24 hours' incubation. After 49 hours, in addition to the above-named structures, the large blood vessels and the choriocapillaris appeared dark. With fructose-1,6-diphosphate, at 24 hours, heavy deposits were present in the suprachoroid, blood vessels, stroma, and choriocapillaris. After 10 hours' incubation with β-naphthylphosphate at 37 C., the choriocapillaris and stroma appeared very dark. The blood vessels and suprachoroid were less densely stained. Adenosine-3-phosphate at 49 hours and adenosine-5-phosphate at 19 hours yield identical pictures, the choroidal stroma being the only structure stained. The enzyme splitting adenosinetriphosphate at pH 9.9 is very active, yielding stains in the choriocapillaris, stroma, and blood vessels at three hours. The suprachoroid appeared diffusely darkened. The stroma and suprachoroid showed activity at four hours with adenosinetriphosphate, at pH 8.25. The choriocapillaris and blood vessels were only slightly stained.

Retina.—No activity is found for the A enzyme system, for the enzymes splitting the adenylic acids or for the enzymes attacking creatine phosphate. The magnesium-activated B system occasionally appears active after long incubation, 48 to 56 hours, with all polyglycol monophosphate substrates. At 24 hours' incubation all layers of the retina showed activity for the enzyme hydrolyzing fructose-1,6-diphosphate. The stain was diffuse, but it appeared to be concentrated in the nuclear and plexiform layers and to be feeble or absent in the rods and cones and in the nerve fiber layer. With adenosinetriphosphate pH 9.9 at 22 hours, the ganglion cell layer and the rods and cones showed the greatest activity. At four hours with adenosinetriphosphate

---

EXPLANATION OF FIGURES 21-26

Figs. 21-26.—*21*, glycerophosphate + Mg; 23 hours. Retina, choroid, and sclera; × 100. Slight activity in the choroid.

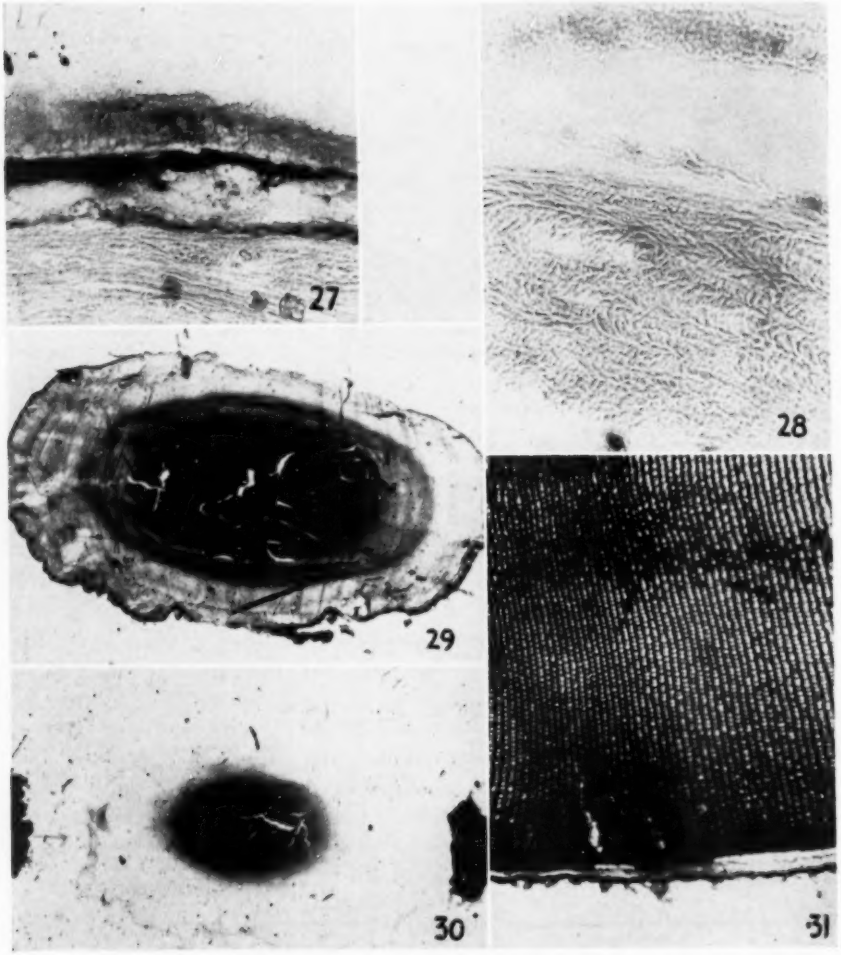
22, β-naphthylphosphate; 37 C.; 10 hours. Choroid and sclera; × 250. Most intense activity in choriocapillaris and pigment epithelium.

23, hexose diphosphate + Mg + boiled kidney extract; 24 hours. Retina, choroid, and sclera; × 100. Note concentration of retinal stain in nuclear and plexiform layers.

24, adenosinetriphosphate; pH 8.25; four hours. Retina, choroid, and sclera; × 100. Relatively greater activity in rods and cones than with hexose diphosphate as substrate.

25, adenosinetriphosphate; pH 9.9; three hours. Retina, choroid, and sclera; × 100. Marked activity in choroid but relatively much less activity in retina than at lower pH (Fig. 24).

26, adenosine-3-phosphate; 46 hours. Retina, choroid, and sclera; × 100. Intense staining in choroid, with little or no activity in pigment epithelium or retina.



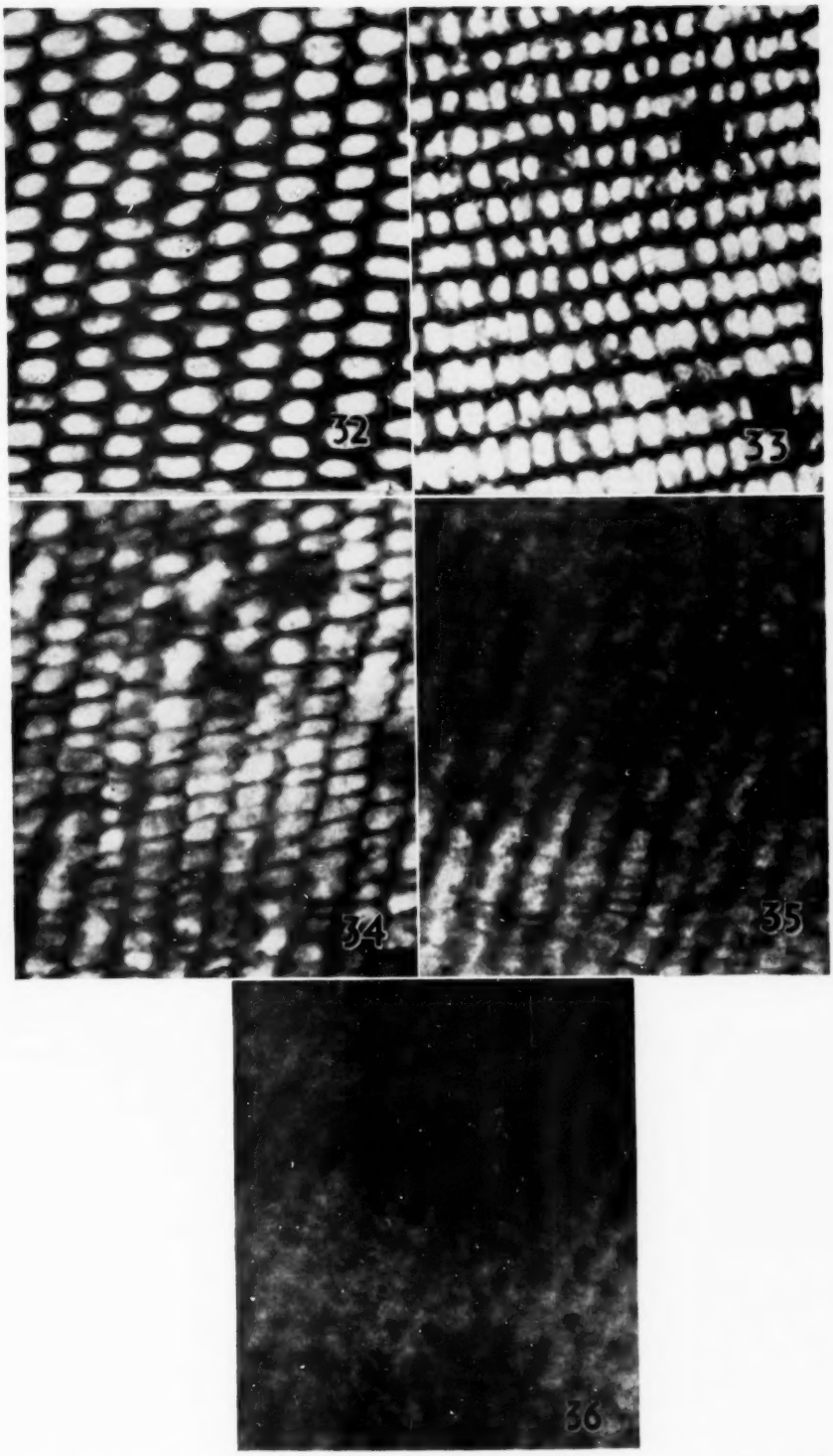
Figs. 27-31.—*27*, adenosine-5-phosphate; 19 hours. Retina, choroid, and sclera; × 100.

28, control (no substrate); 48 hours. Retina, choroid, and sclera; × 100.

29, hexose diphosphate + Mg + boiled kidney extract; 18 hours. Lens; × 100. Staining of nucleus and cortex.

30, control (no substrate); 24 hours. Lens; × 10. Artifactual stain of nucleus but no stain in cortex. Arrows mark lens equator.

31, hexose diphospate + Mg + boiled kidney extract; *22* hours. Equatorial section through the lens near the equator; × 200. Activity in subcapsular epithelium, cell membranes of lens fibers, and nuclei of lens bow.



Figs. *32-36.*—Hexose diphosphate + Mg + boiled kidney extract; *22* hours. Photographs taken in progressive order, starting in subcapsular cortex (Fig. *32*) and moving in toward nucleus (Fig. *36*).

at pH 8.25, all layers were stained. Again, uneven bands of staining density were present, the activity strongest in the rods and cones and the nuclear layers.

Pigment Epithelium.—No activity was found for the A enzymes with the polyglycol monophosphate substrates, or for creatine phosphate, or the adenylic acids. Moderate activity was present for the Benzyme attacking the polyglycol monophosphate substrates and for adenosinetriphosphate at pH 9.9 and pH 8.25, while strong activity was shown for β-naphthylphosphate.

Optic Nerve.—Control sections, incubated in the absence of substrate, showed a diffuse darkening of the medullated portion of the optic nerve. Incubation with the polyglycol monophosphate substrate, β-naphthylphosphate, creatine phosphate, and the adenylic acids resulted in no change in the intensity of the deposit. With adenosinetriphosphate at pH 9.9 and pH 8.25 and with fructose-1,6-diphosphate the deposit was stronger than in the medullated fibers but was still diffuse. The meninges were stained in the presence of these substrates, with the arachnoid appearing rather dark.

COMMENT

The result of these studies on the ocular tissues has confirmed the findings previously reported by Maengwyn-Davies and Friedenwald on the differentiation of substrate-specific alkaline phosphatases by histochemical techniques. With few exceptions, each of the substrates or reaction conditions which yielded a characteristically distinguishable reaction pattern in other organs has been found to have a similarly distinctive distribution in the ocular tissues. No evidence was found in these studies indicating the existence of a generally substrate-nonspecific alkaline phosphatase in fresh frozen sections of the ocular tissues. Studies reported by others (Süllmann [3]; Süllmann and Payot [4]), in which enzyme localization was attempted after fixation and paraffin embedding, have in general yielded the same anatomical pattern irrespective of the substrate used. Thus, for instance, Süllmann found activity in the stroma cells of the fixed, embedded cornea for a variety of substrates, including adenosine-3-phosphate and adenosine-5-phosphate. In the fresh tissue we found no activity for the adenylic acids in these cells. The nature of the so-called nonspecific alkaline phosphatase present in such partially denatured tissue remains obscure.

Much discussion has recently centered on the significance of the intranuclear reaction product regularly found when the enzymatic reaction is tested on fixed, paraffin-embedded tissue. Evidence has been presented by many investigators (Novikoff [5]) indicating that this localization may be due to diffusion artifacts. It should be pointed out that in fresh frozen tissue incubated in the presence of half-saturated sodium acetate, the reaction product is regularly found in the nucleus with some substrates and exclusively extranuclear with others. Under these circumstances, the presence of stain in the nucleus cannot be attributed to diffusion of the reaction product. Diffusion of the enzymes in the presence of half-saturated acetate

3. Süllmann, H.: Histochemische Untersuchungen über Phosphatasen der Cornea, Ztschr. Vitamin- Hormon- u. Fermentforsch. **1**:374, 1947.

4. Süllmann, H., and Payot, P.: Histochemische Untersuchungen über "alkalische" Phosphatase in der Cornea, Ophthalmologica **118**:345, 1949.

5. Novikoff, A. B.: The Validity of Histochemical Phosphatase Methods on the Intracellular Level, Science **113**:320, 1951.

seems very unlikely. The substrates which on short incubation (not over 12 hours) yield intranuclear reaction products are hexose-diphosphate and adenosinetriphosphate (pH 8.25). With the other substrates, intranuclear reaction products are seen only irregularly after very prolonged incubation, 48 to 72 hours. Under these conditions of extensive incubation intranuclear deposits are also found irregularly in control sections incubated without substrate. It seems likely that these delayed deposits result from the hydrolysis of endogenous substrates, e. g., nucleic acid, and are not to be attributed to the substrate tested.

The system of enzymes which attack the polyglycol monophosphates in the absence of added magnesium, and which were designated as the A enzymes by Maengwyn-Davies and Friedenwald, are strongly active in the renal and intestinal epithelium. It seems likely that some of these enzymes may be concerned in active transport of glucose in these organs. Since the A enzymes were not found in the ocular tissues on routine tests, a special effort was made to elicit their activity by raising the concentration of the substrate, by adding boiled kidney extract to replace a possible eluted cofactor, and by adding hydrogen peroxide and zinc ions, which have been shown to be activators for these enzymes in the kidney. No activity for these substrates was found under these conditions. So far as the A enzymes may be regarded as necessary for the active transport of glucose, the absence of these enzymes from the ocular tissues, especially their absence from the ciliary body, may be taken as evidence against the active transport of glucose into the aqueous fluid.

Previous studies (Maengwyn-Davies and Friedenwald [18]) had shown that the B enzyme, which attacks the polyglycol monophosphate substrates in the presence of magnesium, was to be found in all the tissues and organs studied. The conclusion was suggested by these authors that this enzyme or enzyme system was a component of the glycolytic system. In the present study, we have not found the B enzyme in the crystalline lens, cornea, or certain other ocular tissues. Attempts to reveal this enzyme by using increased concentrations of substrate and of magnesium, and by adding boiled kidney extract, all failed. The addition of hydrogen peroxide as a potential activator was also unsuccessful. Since there is no doubt that the lens and cornea contain the enzymes necessary for glycolysis, it is to be concluded that either the B enzyme is not a necessary component of the glycolytic system or that the inactive tissues contain an endogenous inhibitor.

In two ocular tissues artifactual staining was encountered, i. e., a deposit of cobalt sulfide after incubation in the absence of substrate. These two tissues were the lens nucleus and the medullated portions of the optic nerve fibers. It is evident that these tissues contain some substance that binds calcium or cobalt ions. The offending material in the lens nucleus could be removed by washing the section in bathing solution prepared without the addition of sodium acetate. Under these conditions, the controls, incubated without substrate, were devoid of reaction product, while those incubated in the presence of hexose diphosphate or of adenosinetriphosphate showed activity in the lens cortex, but little or no activity in the lens nucleus. It is evident that the offending substance is water-soluble but is held in the tissue in the presence of high concentrations of sodium acetate. On the other hand, similar extraction experiments failed to remove the offending substance from the medullary sheaths of the optic nerve fibers.

SUMMARY

The histochemical localization of a number of substrate-specific alkaline phosphates in the ocular tissue of the rabbit is shown.

*Activity Distribution for Various Substrates and Incubation Conditions**

	Monophosphate Polyglycol						Adenosine-triphosphate			
	Enzyme A	Enzyme B	CrP	CrP $MgCl_2$	BN	HP_2	pH 9.9	pH 8.25	A-3-P	A-5-P
Lens	−	−	−	−	−	+	+	+	−	−
Iris	−	−	−	−	−	+	+	+	−	−
Ciliary body	−	+	−	−	+	+	+	+	+	+
Cornea	−	−	−	−	−	+	+	+	+	+
Conjunctiva	−	+	+	−	+	+	+	+	+	+
Sclera	−	−	−	−	+	+	+	+	−	−
Choroid	−	−	−	−	+	+	+	+	+	+
Retina	−	−	−	−	+	+	+	+	−	−
Pigment epithelium	−	+	−	−	+	+	+	+	−	−
Optic nerve	−	−	−	−	−	+	+	+	−	−

* CrP indicates creatine phosphate; BN, β-naphthylphosphate; HP_2, fructose-1,6-diphosphate; A-3-P, adenosine-3-phosphate, and A-5-P, adenosine-5-phosphate.

FLICKER SICKNESS

GEORGE A. ULETT, M.D. Ph.D.
ST. LOUIS

INTERMITTENTLY flashing light is used clinically as a technique for producing abnormal (paroxysmal) rhythms in the electroencephalogram to aid in the diagnosis of epilepsy. Recently, reports have appeared in which this technique is used to trigger seizures in the convulsive treatment of psychotic patients (photoshock). It is also used as a research tool in clinical investigation.[1] With such wide use of this stimulus, it seems wise at this time to report upon certain untoward effects of intermittent light that can occur to patient and researcher alike. The vivid subjective visual sensations induced by this means (Prevost-Fechner-Benham effect) have long been known.[2] Walter and Walter,[3] in 1949, noted that the immediate effects of intermittent photic stimulation may, in addition, include sensations of spinning, vertigo, fear, and visceral disturbances.

In our own laboratory during the past three years my colleagues and I have observed the effects of intermittent photic stimulation on well over 500 normal subjects and psychiatric patients. The light stimulus used in our laboratory consists of a 1,000-watt tungsten-filament 16-mm. moving picture projection lamp which is directed through a suitable lens system upon an opal glass screen. The stimulus is in the form of a circle about 30 in. (75 cm.) in diameter which fills the visual field of the observer with a light of 100 to 200 foot-candle (f.-c.) intensity. The light beam is interrupted by means of an electronically operated pendulum-type shutter, and the frequencies used are from 2 to 30 flashes per second.

We have reported elsewhere the ability of such a stimulus to reproduce previously experienced symptoms in psychiatric patients, and since that report [4] we have had further confirmation of these observations, including the reproduction of an anxiety attack, in which the patient alternately cried and laughed and was unable to arise from the recording-room chair of her own volition for approximately 30

From the Department of Neuropsychiatry, Washington University School of Medine.

1. Ulett, G. A.: The Use of the Photically Activated EEG as a Research Tool in Psychiatry, Psychosom. Med. **15**:66-83, 1953.

2. Cohen, J., and Gordon, D.: The Prevost-Fechner-Benham Subjective Colors, Psychol. Bull. **46**:97-136, 1949.

3. Walter, V., and Walter, W. G.: The Central Effects of Rhythmic Sensory Stimulation, Electroencephalog. & Clin. Neurophysiol. **1**:57-86, 1949.

4. Ulett, G.; Gleser, G.; Lawler, A., and Winokur, G.: An Experimental Investigation of Development of an EEG Index of Anxiety Tolerance by Means of Photic Stimulation: Its Validation by Psychological and Psychiatric Criteria, Report No. 4, School of Aviation Medicine Project 21-37-002, Randolph Field, Texas, 1952.

minutes after photic stimulation. For the following 12 hours this patient complained of a severe headache and experienced headaches of less intensity and shorter duration for three days after the procedure. Her resting electroencephalographic pattern before and after photic stimulation was normal, and during such stimulation the only brain-wave alteration was photic driving of the brain-wave pattern occurring in 1 : 1 ratio with the frequency of flashing light.

Three hundred six control subjects have been seen in our laboratory. Eighty-seven of these showed some reaction, such as visceral (nausea, headache, etc.) or kinesthetic (body moving in space) sensations in varying degrees. Sixteen of this group had disturbances of consciousness, including fainting, syncope, and convulsive phenomena.[5]

Among 40 psychotic patients receiving photoshock, nausea has appeared transiently in only 3, despite the fact that in all cases the light stimulus, used in conjunction with Azozol (4-cyclohexyl-3-ethyl-1,2,4-triazole), produced severe myoclonic reactions or generalized seizures. In one patient dimenhydrinate (Dramamine) was used, with partial success in relieving the nausea.

Dysphoric symptoms similar to those described above may be of diagnostic use, and their production during a single session of testing has, to our knowledge, produced no permanent harmful effects. In the case of persons who must work around the flicker stimulus every day, however, these side-effects can be a more troublesome problem. This has been the case with one electroencephalographic technician who works with this stimulus daily and who has been found to be hypersensitive to flicker frequencies below 8 flashes per second. Exposure to such a frequency for five minutes or more can produce in her a dizziness and indescribable dysphoria which may last for several hours and prove to be quite incapacitating. These symptoms are more intense after a 12-hour fast. Other frequencies have little or no effect upon her. We have observed a similar phenomenon in two physicians who have assisted in the laboratory. One of these, who has some paroxysmal activity in the resting electroencephalogram, assisted with photoshock treatments and was exposed to the flashing light for a period of about 20 minutes on three occasions. She found that each time she had no immediate effects but that two to three hours later she became nauseated and dizzy to the point where bed rest was necessary. On each occasion there was confusion of thinking, and on one occasion some reading and speech disability. Another physician, who has had none of these symptoms and who has been exposed to intermittent light stimulation for as long as three hours at a time without discomfort, manifested, after working with this stimulus for over two years, chronic symptoms of gastrointestinal discomfort, for which he had a complete medical examination, including a gastrointestinal series, but without definitive diagnosis. With an eight weeks' vacation from the laboratory, the symptoms cleared up, only to return again when work was resumed. Such symptoms have now entirely disappeared with care in avoiding exposure to the intermittent light stimulus, by his staying out of the treatment room and observing through a colored screen.

5. Ulett and others.[4] Ulett, G.; Gleser, G.; Starr, P.; Haddock, J.; Lingley, L., and Lawler, A.: Further Studies Toward the Development of an Electroencephalographic Screening Technique, Project Report No. 5, U. S. Air Force School of Aviation Medicine, San Antonio, Texas, 1953.

Nurses who assist with the treatments have given complaints of nausea and dizziness with such frequency that we have come to look upon "flicker sickness" as a definite occupational disturbance of those who work around such flashing light. Similar observations have been reported to us by others working in this field.[6] We are at present constructing a stimulating device which will present the flashing light only to the patient. Until this is in use, we shall continue to protect our laboratory personnel by issuing colored glasses to all who are adversely affected by intermittent photic stimulation.

SUMMARY

Exposure to intermittently flashing light can result in a variety of untoward symptoms including dizziness and nausea, as well as psychic phenomena. Some of these may persist for several hours after stimulation.

6. Daly, D., and Bickford, R. G.: Personal communication to the author, Feb. 4, 1953.

NATURE OF THE CORNEAL "CANALS" PRODUCED BY PERILIMBAL INJECTIONS OF HYDROGEN PEROXIDE

BENJAMIN FRIEDMAN, M.D.
NEW YORK

ATTEMPTS at outlining corneal channels have been numerous and are well known, but no unimpeachable results have thus far been obtained. The most frequently quoted are the experiments of von Recklinghausen in staining the superficial corneal layers with silver and the efforts of Bowman to inject the stroma with metallic mercury. In 1909 Krusius [1] utilized oxygen liberated *in situ* on injection of hydrogen peroxide (H_2O_2) in the perilimbal region of the rabbit's eye to force open what he thought were corneal lymphatics. He described a snow-white ring at the limbus from which the gas infiltrated the cornea in rows of bubbles. He considered these spaces to be "preformed" and stated that they were lined with endothelium. Later, Magnus [2] extended this principle to other tissues of the body as well as the eye, but only his findings in connection with the cornea are of primary interest to us at the moment. In the dogs' cornea Magnus found that two systems of tubules are revealed; these lie at different levels and nowhere communicate with each other. The anterior, or superficial, set is filled by injecting the perilimbal conjunctiva. Behind this lies the deeper system, which can be filled only by injecting the episcleral tissues. These deeper channels lie in parallel bundles, and these bundles lie at several levels, as might be expected from our knowledge of the cornea. The tubules simulate bubbles of air caught in ice. They take a straight course, and each set crosses its neighbors at an acute angle. Magnus performed these experiments on living animals, the eye being immersed in warm water, with an immersion microscope at a magnification of $\times$ 73, and photographs were obtained under a magnification of $\times$ 42. He was unable to make stained sections of the cornea because the spaces were lost in the handling of the tissues. Krusius had employed a 30% solution of H_2O_2 in his experiments, and Magnus considered the resultant spaces to be explosion products, as, indeed, the photomicrograph appended to the report of Krusius bears witness. Magnus, on the other hand, injected 1% to 3% H_2O_2 and found no evidence of tearing in his observations on the living tissues. The canal appeared sharply defined and circular in cross sections. More extensive experiments on eyes were elaborated by Magnus and Stübel,[3] and by Stübel.[4] They both found that injection of the lens gave rise to large round bubbles, irregular in their distribution, which tore the lens tissue during their expansion. Stübel found in the corneas of the numerous species which she examined that at least one

1. Krusius, F.: Arch. Augenh. **64**:42, 1909.
2. Magnus, G.: Deutsche Ztschr. Chir. **175**:147, 1922.
3. Magnus, G., and Stübel, A.: Ber. deutsch. ophth. Gesellsch. **43**:36, 1922.
4. Stübel, A.: von Graefes Arch. Ophth. **110**:109, 1922.

canal system, and in most cases two canal systems, are regularly and typically filled by the gas—the deeper appeared to be similar to the tubules of Bowman, and the other, superficial, to the canals of von Recklinghausen. Stübel also found a direct communication between the deeper canals and the lymph vessels of the limbus. Frozen sections of a pig eye revealed superficial and deep spaces; there were no tears in the cornea, and the epithelium was intact. No endothelial walls were visible. There were no communications between the corneal spaces and the anterior chamber. She obtained equally good results with the eyes of dead animals.

Magnus and Stübel objected to the injection of dyes into the cornea on the ground that the passages elected by the dye are not necessarily through the lymphatics. The injection of semisolid material causes too many pressure artifacts; on the other hand, if the pressure is not strong enough, filling fails to occur. They felt that these shortcomings were avoided by the H_2O_2 method and that the corneal spaces were true lymphatics, for the reasons that (1) since the oxygen gas is liberated on contact with the lymph, only the lymphatic channels are opened; (2) only gentle pressure is necessary during the injection; (3) the corneal tissues are not torn; (4) the constancy of form of the corneal figures supports the idea of preformed channels, and (5) in the lens, the gas takes the form of globular bubbles, which are of inconstant pattern and which tear the lens tissue, quite a different picture from the sharply outlined corneal channels.

PRESENT STUDY

These conclusions have not been given credence by authoritative writers,[5] but, as far as I am aware, there has been no recored repetition of Magnus' and Stübels' experiments. I was prompted, therefore, to attempt the verification of their results. Freshly enucleated steer eyes were injected with 3% H_2O_2. Observations were made with the slit lamp and the binocular loupe, and sections were obtained in both paraffin and celloidin bases. Frozen preparations were also made.

When the conjunctiva was injected near the limbus, a large number of tiny white blisters immediately formed along the limbal margin near the site of injection. These bullae were pure-white and gave the appearance of froth. A number of very fine, gray, hair-like channels were seen with the slit lamp to extend from the marginal blebs a short way into the cornea. Then, suddenly, as though all resistance had been overcome, they raced toward the center of the cornea for a distance of 5 or 6 mm. They became easily visible to the naked eye. Their course was wavy, but in the main they paralleled each other. Some of the channels gave off fine branches, and a few anastomoses near the terminals were noted. The channels were superficial, and they appeared even and unbroken. If the epithelium was scraped away with a knife, the channels were included in the destruction, although, rarely, a few might remain in the cornea proper. Owing to the high solubility of oxygen, most of these fine lines disappeared after about a half-hour. Some of them degenerated into heavier, spindle-shaped bubbles, which eventually also vanished. I was unable to obtain celloidin sections of these superficial canals because they were lost in the process of preparation, but I obtained a few examples in frozen sections. They lay within the lowest rows of the epithelial cells, above Bowman's membrane. The

5. Duke-Elder, W. S.: Text-Book of Ophthalmology, Vol. 1, London, Henry Kimpton, 1932, p. 47. Bailliart, F.; Coutela, C.; Redslob, E., and Velter, E.: Traité d'ophthalmologie, Paris, Masson & Cie, 1939, Vol. 1, p. 549.

lumens of the canals were flattened anteroposteriorly; the edges were ragged, with torn epithelial lining. Some of the canals could be seen close together, separated only by thin partitions of compressed epithelial cells.

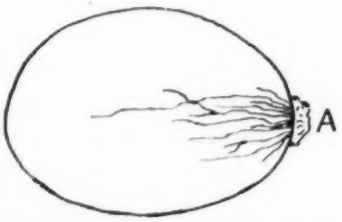


Fig. 1.—Macroscopic appearance of superficial canals; *A* represents the site of injection, from which the intraepithelial canals radiate.

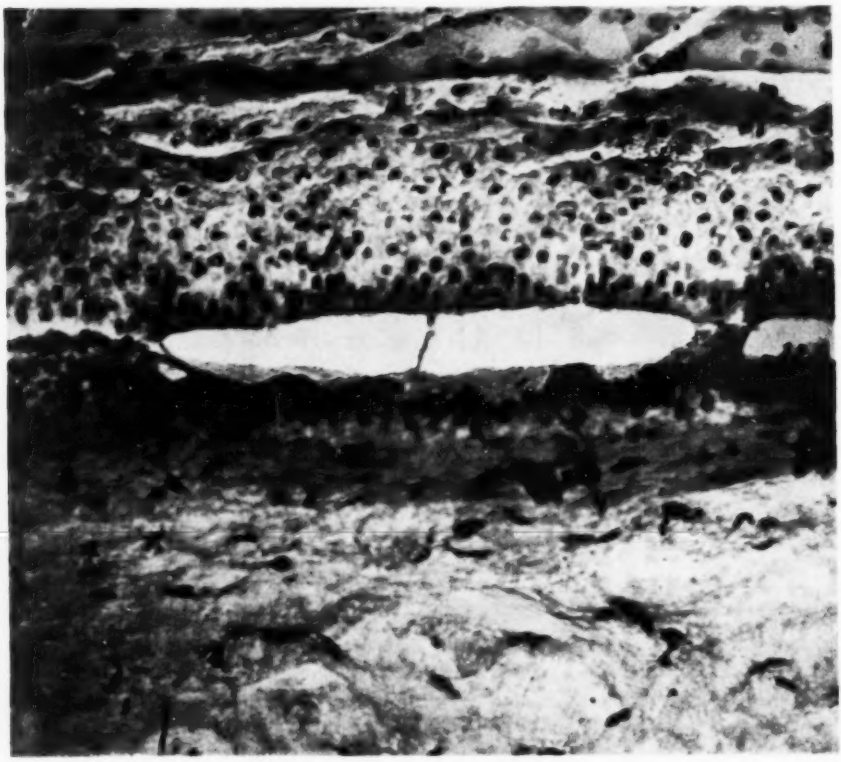


Fig. 2.—Photomicrograph of superficial corneal canals; cross section.

When the episcleral tissue was injected near the limbus, the typical extensions into the deeper layers of the cornea became evident. If more solution was introduced, these progressed very far toward the pupil. Once the expansion centrally had begun, it traveled very quickly; at times the movement was too rapid to be

observed with the eye. These channels were straight; they did not branch as a rule, although occasionally a small twig could be seen at right angles to the main stem. They did not anastomose with each other, and they radiated fanwise from the site of injection. They followed the lamellar arangement of the corneal strata, and the adjacent groups crossed each other. There was no difficulty whatever in seeing these channels with the naked eye.

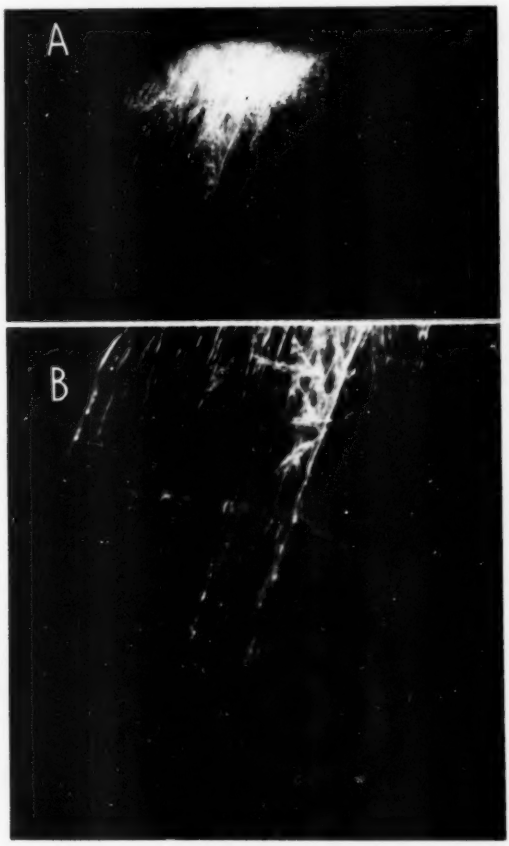


Fig. 3.—*A*, macroscopic photograph of deep corneal canals; *B*, portion of *A* enlarged.

Injection directly into the cornea produced the same sort of canals. If a drop of H_2O_2 was placed on a spot from which the corneal epithelium had been removed, an abundant formation of deep canals resulted.

An interesting sight observable during the injections was the very rapid filling of the perivascular lymphatics in the conjunctiva. The gas expanded not only toward the limbus but also backward, along the sclera.

Microscopic examination of the deep corneal canals in cross section disclosed a number of almost perfectly round holes at various levels of the cornea. They

seemed to be lined by a darkly stained condensation of tissue. An occasional fixed cell, flattened within this "lining," might be mistaken for an endothelial cell. The pressure against the wall of the canal probably accounted for the condensation line. It is also possible that the contact of the unfixed tissue with the nascent oxygen produced chemical changes, which resulted in a heavier staining of the lumen

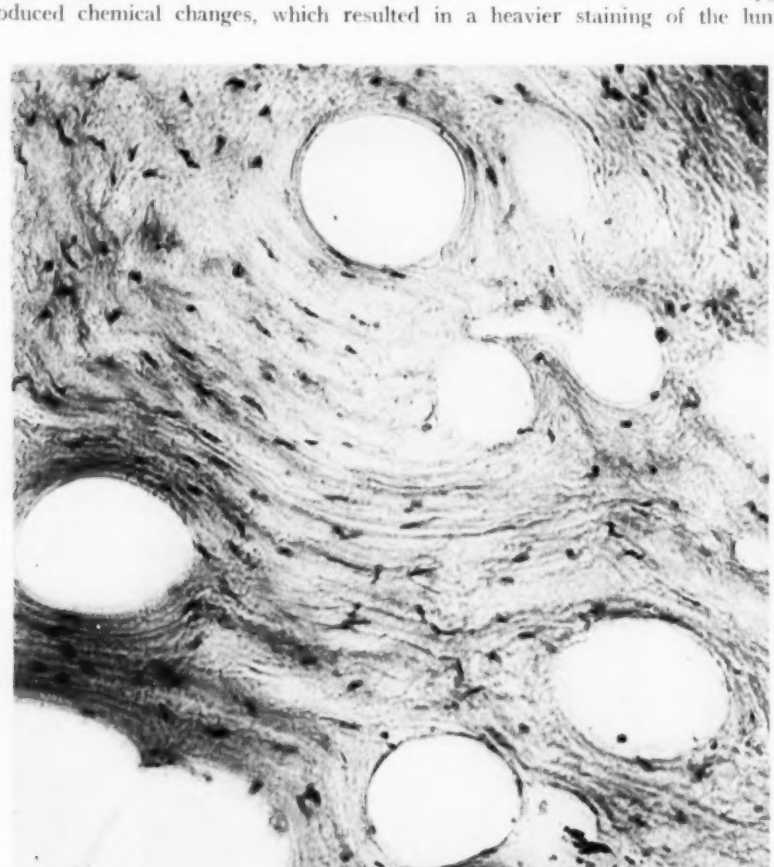


Fig. 4.—Photomicrograph of deep corneal canals; cross section.

surface. The lumens were very smooth, and there was no fragmentation of corneal tissue.

When a considerable amount of H_2O_2 was injected, the tissues became stiff from the pressure generated by the expanding gas, and bubbles in large numbers could be seen entering the anterior chamber through the angle. This danger must be remembered if the use of H_2O_2 by injection is contemplated in the human eye.

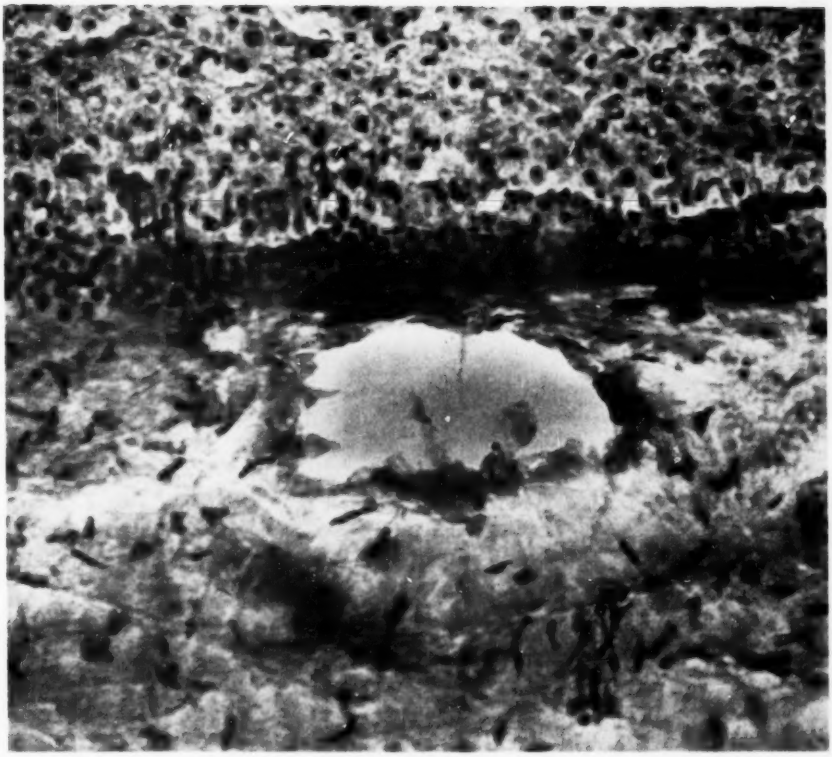


Fig. 5.—Deep corneal canal produced by excessive gaseous pressure; cross section.

Fig. 6.—Effects of excessive gaseous pressure in the corneal stroma and epithelium.

Microscopic sections of the cornea then revealed a violent destruction of tissue boundaries. The whole cornea was gas-riddled, and even the epithelium was blown up by the eruptive force of the oxygen.

An interesting formation of canals became evident when I injected a cornea which contained a dense, centrally placed opacity. A system of canals radiated from the opacity in the deep layers of the cornea, not in straight lines, but in a tortuous, Medusa-head design. Similar canals also extended inward from the limbus, also in the deep layers of the cornea. The impression obtained was that a large number of invisible blood vessels in the parenchyma were suddenly filled by the expanding gas.

COMMENT

It might be well to discuss the suppositions with which Magnus and Stübel support their identification of the canals as lymph channels.

1. Oxygen is liberated from H_2O_2 upon contact with a specific enzyme, catalase. However, catalase is found not only in the lymph but in the intercellular fluid, and in the cell protoplasm as well. Hence, it is not justifiable to suppose that the gas finds its way only into such channels as bear lymph, and it is therefore not reasonable to assume that the spaces operated by the nascent gas are necessarily lymph spaces. There is much more reason to believe that they result from intercellular cleavage lines.

2. It is true that only gentle pressure on the syringe piston is required to bring out the canals, but an additive factor must be considered. A 3% solution of H_2O_2 when decomposed gives off ten times its volume in gas, and the pressure within the tissue spaces becomes infinitely greater than the normal pressure in the lymph capillaries or the intercellular spaces. Simple palpation of the tense conjunctiva with the finger will convince one of this. The expansive effect of the gas is superimposed on the distention caused by the liquid H_2O_2. The gaseous expansion continues to balloon the tissues long after the injection of H_2O_2 has ceased. The gas itself acts as a dissecting tool, and once a line of cleavage has been found, the separation occurs at a very rapid pace. The rate of speed of the canals is certainly faster than it would be if their progress depended on the slow seepage of the H_2O_2 solution into the tissues. It must be remembered, in connection with this point, that dead eyes were used and that no circulatory assistance was offered to the injected H_2O_2 in its spread. The manner in which the larger tubules form is anything but slow and gentle, and terrific force (speaking in terms of the natural pressure of tissue fluids) is required to effect such separations in the leathery cornea.

3. The formation of clean-cut canals in the corneal stroma is possible because fragmentation of the tissues does not occur easily, owing to the tough consistency of the cornea. If greater pressure is generated, the lamellae are torn apart. The fact that intact canals are visible before the bursting point is reached is no indication that the spaces have been preformed. In the epithelium, where the cellular structure is easier to disrupt, the gas actually tears its way through at once.

4. The general constancy of form of the corneal canals is explained by the uniformity of corneal structure. The corneal meshwork is no different in one sector than it is in another, and it is not surprising that the intracorneal bubbles should be molded to repetitive patterns. Each tissue will create its own peculiar boundaries

for gas liberated within its structure, and upon such boundaries depends the shape of the bubbles, provided, of course, that the gas pressure is not sufficiently high to burst completely through the restraining tissue.

5. The lens is characterized by successive laminations of tissues, but these layers are exceedingly soft and are unable to offer effective resistance to the expanding gas. The escaped bubbles, for physical reasons, will assume a globular form, just as bubbles of air in the aqueous or the vitreous are globular. It does not follow that the corneal bubbles lie in preformed spaces because they are linear rather than globular.

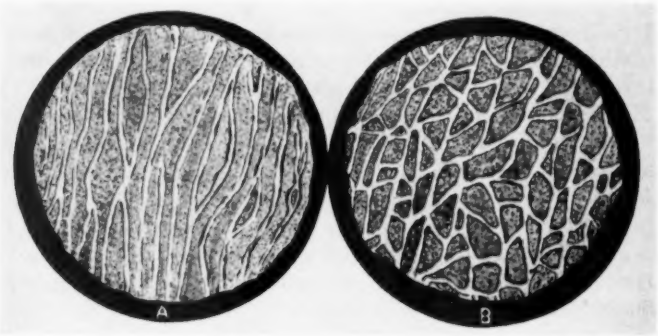


Fig. 7.—*A*, entoptic appearance of vertical corneal channels; *B*, entoptic appearance of communicating vertical, horizontal, and oblique channels.

SUMMARY AND CONCLUSIONS

There is no evidence that the deep canals of Krusius, Magnus, and Stübel are other than artificial separations of the elements of the corneal stroma.

The superficial canals are definitely artifacts; they are passageways frankly torn through the substance of the epithelial layers.

The subject is not a closed one. It is certain that the endothelial requisites for a true lymphatic system are not to be found in the cornea, but by entoptic methods [6] it is possible to demonstrate that some kind of channels do appear to exist (Fig. 7). All we can say is that as yet anatomic preparations have yielded only misleading artifacts and have been too crude to permit us to draw final conclusions.

160 W. 73d St. (23).

6. Friedman, B.: Arch. Ophth. **28**:285, 1942.

EVALUATION OF WOUNDS OF THE RABBIT CORNEA TREATED WITH CALSULFHYDRYL (HYDROSULPHOSOL)

ROBERT E. ROCKNEM, M.D.
MINNEAPOLIS

SINCE 1942 several clinical investigations have been published describing the increased healing rate of corneal wounds treated with calsulfhydryl (Hydrosulphosol [1]). This sulfhydryl solution has been reported by Mellon,[2] Cruthirds,[3] Pierce,[4] Mullen,[5] and Kuhn [6] to be highly effective but it was used clinically by these authors without controls. Efforts have therefore been made to confirm these clinical observations by carefully controlled chemical injuries inflicted on rabbit corneas, but these attempts have been mostly unsuccessful. In a large series of rabbits reported by Harley [7] there was no demonstrable increase in rate of healing in corneas injured with acids and alkalies when calsulfhydryl was used, and, in an earlier article, Williams and Bissel [8] were also unable to increase healing with sulfhydryl solutions.

The present study was undertaken therefore to evaluate the effect of calsulfhydryl on a controlled series of rabbits corneas injured by abrasion or by acid or alkali burns.

METHOD

Three groups of rabbits were used: (1) 9 rabbits whose corneas were injured with 2% sodium hydroxide; (2) 6 rabbits whose corneas were injured with 3% hydrochloric acid, and (3) 10 rabbits whose corneas were abraded. The right eye of each rabbit was selected for tests of calsulfhydryl, and the left eye was used as a control.

Funds used to conduct this work were furnished by the Crosby Foundation, Inc.

The Hydrosulphosol used in this experiment was furnished by E. C. Lientz & Co., Inc.

This work was originally submitted as a thesis to the faculty of the Graduate School of the University of Minnesota in partial fulfilment of the requirements for the degree of Master of Science in Ophthalmology.

1. Hydrosulphosol is the registered trademark of E. C. Lientz & Co., Inc., for their brand of calsulfhydryl, the generic name for the aqueous dispersion of sulfur complexes of calcium polysulfides and thiosulfates containing a labile sulfhydryl group.

2. Mellon, R. R.: A New Sulfhydryl Solution for Treatment of Burns, Indust. Med. **11**:14, 1942.

3. Cruthirds, A. E.: Sulfur Metabolism and Its Relation to Wound Healing in Ophthalmology and Otolaryngology, Tr. Am. Acad. Ophth. **53**:596, 1949.

4. Pierce, W. F.: The Use of Sulfhydryl Solution in the Treatment of Burns: Preliminary Report, Am. J. Surg. **53**:434, 1941.

5. Mullen, C. R.: Decisions in Eye Injuries, J. Aviation Med. **21**:58, 1950.

6. Kuhn, H. S.: The Use of Hydrosulphosol (Sulphydryl) in the Treatment of Chemical and/or Thermal Burns of the Eyes, Tr. Am. Acad. Ophth. **53**:157, 1948.

7. Harley, R. D.: An Experimental Study on the Evaluation of Hydrosulphosol in the Treatment of Ocular Injuries Due to Chemical Burns, Tr. Am. Ophth. Soc. **49**:557, 1951.

8. Williams, R. H., and Bissel, G. W.: The Effect of Topical Application of Vitamins and Some Other Chemicals on the Healing of Wounds, Arch. Surg. **49**:225, 1944.

GROUP 1.—Sedation was produced by intraperitoneal injection of 50 mg. of pentobarbital (Nembutal) sodium and the animals were anesthetized with topical administration of 0.5% tetracaine hydrochloride. After maximum hypnosis and anesthesia were attained, 1 drop of 2% NaOH was placed on one cornea from a height of 1 cm. Each drop contained 0.08 cc. of solution, the same dropper being used in all the eyes treated in this group. The caustic solution was allowed to remain in contact with the eye exactly one minute, after which the cornea and the conjunctival sac were washed for two minutes with a stream of isotonic sodium chloride solution. Atropine was placed in each eye, followed by 5% calsulfhydryl in castor oil in the right eye and castor oil in the left eye. Atropine was placed in each eye daily thereafter, and the calsulfhydryl and the castor oil were instilled three times daily.

GROUP 2.—Premedication was given by intraperitoneal injection of pentobarbital sodium, followed in one-half hour by drop ether anesthesia. When surgical anesthesia was attained, tantalum wire sutures were placed in the upper and lower tarsal plates. Each cornea was injured individually with a 5-mm. disk of filter paper moistened with 3% hydrochloric acid. The filter paper was allowed to remain in contact with the cornea exactly one minute, after which the cornea and the conjunctival sac were irrigated with isotonic sodium chloride solution. Atropine was placed in each eye. Calsulfhydryl gel was instilled in the right eye and 3% methylcellulose U. S. P. in the left eye. (These substances were used thereafter twice a day.) A silk suture was then tied across the wire sutures to close the lids.

GROUP 3A.—The six rabbits were given 50 mg. of pentobarbital sodium intraperitoneally, followed by topical application of 3 drops of 10% cocaine. After the rabbits were quiet and well anesthetized, each cornea was abraded of all epithelium with the long edge of a spud. The completeness of the abrasion was determined by means of 2% fluorescein sodium. Atropine was placed in each eye daily. Calsulfhydryl 5% in castor oil, was then instilled in the right eye and castor oil in the left eye, three times daily thereafter.

GROUP 3B.—The four rabbits received premedication with 50 mg. of pentobarbital sodium, followed by drop ether anesthesia. Wire sutures were placed in each tarsal plate, after which 3 drops of 10% cocaine was instilled to soften the corneal epithelium. The entire epithelium was abraded and the completeness checked with fluorescein. Atropine was placed in each eye then and daily thereafter. Calsulfhydryl gel was instilled in the right eye and 3% methylcellulose in the left eye. The wire sutures were tied together with silk suture, which was cut and retied twice a day for instillation of the calsulfhydryl and methylcellulose. All corneas were stained with 2% fluorescein sodium daily, and the time required for epithelium to cover the injured cornea was recorded.

RESULTS

The longest time for epithelization (14 days) was required by corneas injured with 2% sodium hydroxide. Burns with 3% hydrochloric acid required four to five days and abrasions three days. In spite of care used in injuring the corneas, three of the rabbit corneas injured with sodium hydroxide did not display equal initial reactions; consequently, they were eliminated from the series.

The injuries of the corneas receiving 3% hydrochloric acid appeared equal after the second day but progressed quite differently thereafter. The corneas treated with calsulfhydryl gel were consistently hazier and more edematous than those treated with 3% methylcellulose only. In no case did the staining areas heal faster when treated with calsulfhydryl, but the average time was not significantly different in the two groups (three to three and a half days).

The first group of abrasions healed equally when treated with 5% calsulfhydryl in castor oil and with castor oil. The time required was the same as that found in other series of corneal abrasions in rabbits.

The second group of abrasions, which were treated with calsulfhydryl gel, did not behave like those treated with the castor oil preparation but reacted in a way

similar to that of the acid burns; corneal edema was noted, which disappeared when the drug was discontinued. The average time required for epithelization was not significantly different, however.

COMMENT

The production of equal injuries was not a problem with the abrasion technique, but in the groups injured with 2% sodium hydroxide and 3% hydrochloric acid the difficulty of obtaining equal injuries was very apparent. After several trials with the same medicine dropper held at a height of 1 cm., uniform injuries could be obtained in most of the corneas injured with 2% sodium hydroxide. In the 3% hydrochloric acid series the filter-paper-disk technique produced dependable and uniform results and seemed more reliable than the drop technique. None of the animals in the hydrochloric acid series had to be eliminated because of variation in the initial appearance of the injuries.

The second group of abrasions and the acid burns were given the benefit of forced lid closure because of Kuhn's[6] emphasis on proper lid closure in treatment of human eye burns.

As in other series of this kind in which rabbit corneas were used for study, there was no evidence of increased rate of epithelization of the corneas treated with calsulfhydryl. Furthermore, two side-effects were noted: (1) increased conjunctival reaction when calsulfhydryl in castor oil was used, and (2) increased corneal turgescence when calsulfhydryl gel was used. Both these reactions were observed consistently.

SUMMARY

Twenty-five rabbits were used in a study of the effect of calsulfhydryl (Hydrosulphosol) on the rate of epithelization of corneas injured by 2% sodium hydroxide, 3% hydrochloric acid, or mechanical abrasion.

Six rabbit corneas injured with 2% sodium hydroxide epithelized in 14.5 days with use of 5% calsulfhydryl in castor oil, as compared with 12.5 days with use of castor oil alone.

Six rabbit corneas injured by 3% hydrochloric acid and treated with calsulfhydryl gel required 4.5 days to epithelize, as compared with 4 days for 3% methylcellulose used as a control.

Six rabbit corneas injured by complete abrasion and treated with 5% calsulfhydryl in castor oil and six corneas abraded and treated with castor oil alone showed equal rates of epithelization.

Four rabbit corneas abraded and treated with calsulfhydryl gel were covered by epithelium on the same day as the controls treated with 3% methylcellulose.

Calsulfhydryl gel produced a corneal edema, not noted in control corneas treated with 3% methylcellulose.

645 Medical Arts Bulg.

VISUAL FIELD CHANGES IN OPTIC NEURITIS

MAX CHAMLIN, M.D.
NEW YORK

IN USING the term "optic neuritis," I refer both to the intraocular and the retrobulbar varieties, in other words, to papillitis as well as to retrobulbar neuritis.

Wilbrand and Sanger divided optic neuritis into three main classes: perineuritis, axial neuritis, and transverse neuritis. Traquair [1] quotes Wilbrand and Sanger and uses this classification in his descriptions. Duke-Elder [2] also makes use of this classification, explaining further that in using the term "optic neuritis" he means to include the intraocular form, i. e., papillitis, as well as retrobulbar neuritis, in which no fundus changes are shown. He then speaks of a type of neuritis that occurs within the anterior portion of the optic nerve, close to the disc, describing it as showing slight edema of the nerve head.

Walsh,[3] in his textbook on neuro-ophthalmology, also uses the Wilbrand and Sanger classification but deviates somewhat from the usage of the terms in that he does not apply the term "retrobulbar neuritis" strictly in accordance with the true meaning of the words, but, rather, uses this term to denote involvement of the papillomacular bundle, with the resultant central defect, regardless of whether such involvement is in the intraocular portion of the optic nerve, as in papillitis, or in the retrobulbar portion. He justifies this use of the term "retrobulbar neuritis" by citing the frequency with which retrobulbar neuritis selectively involves the papillomacular bundle, together with its resultant central defect. He quotes Ronne as the basis for this concept.

While Walsh's concept of the anatomical and pathological process is undoubtedly the same as that of others, it seems rather confusing that he should prefer the use of the term "retrobulbar neuritis" to denote a particular type of field defect, rather than what the term actually means.

As a matter of fact, even the term "neuritis" is technically incorrect inasmuch as in some cases what we refer to as optic neuritis is really not inflammation of the optic nerve, as the term implies, but degeneration or demyelination, such as that caused by the plaque of multiple sclerosis. However, it is not my purpose to discuss terminology, except to clarify the various names as used in this paper. For these reasons, I shall continue to use the term "optic neuritis" as including both the intra-

1. Traquair, H. M.: An Introduction to Clinical Perimetry, Ed. 6, St. Louis, C. V. Mosby Company, 1949, p. 162.

2. Duke-Elder, W. S.: Text-Book of Ophthalmology, Vol. 3, St. Louis, C. V. Mosby Company, 1940, p. 2967.

3. Walsh, F. B.: Clinical Neuro-Ophthalmalogy, Baltimore, Williams & Wilkins Company, 1947, p. 357.

ocular variety (papillitis) and the retrobulbar variety, or retrobulbar neuritis. This classification refers to the anteroposterior distribution of the site of involvement of the optic nerve and is independent of the Wilbrand and Sanger classification, which really refers to the transverse distribution of involvement (i. e., from axial to peripheral), at a particular level of the optic nerves. The Wilbrand and Sanger classification will be mentioned again, later on in this paper, in relation to the particular field defects that their terminology implies.

The visual field defect is important not only in diagnosing optic neuritis but also in evaluating optic atrophy. Thus, it has been my experience that if one is to decide whether the "pallor" of a disc is physiological or pathological, the most reliable criterion lies in the study of the visual field. Thus, if a disc looks pale but complete field studies, including minimal testing of the central and peripheral fields (several isopters) and blind spots, give normal findings, one may safely say that the pallor is physiological. On the other hand, a field defect would indicate that the condition is true optic atrophy, and the type of field defect, coupled with the ophthalmoscopic picture and the clinical history, may well indicate the nature of the disease process having produced this atrophy.

The accepted teaching is that the typical field defect in optic neuritis is a central scotoma, and this is, with some later explanations, essentially correct. We are also told that paracentral defects and involvement of the periphery occur, but rather infrequently, as compared with the central defects. Thus, Traquair says that sector defects may occur, and that one may even get annular defects. He also mentions the fact that peripheral fields are not infrequently affected. Walsh agrees that the central scotoma is commonest, and then notes that paracentral scotomas or sector or quadrantic defects also occur, but does not mention the frequency of such occurrence. Again, Duke-Elder mentions that the loss of field is usually central, although there may be paracentral, cecocentral, sectoral, or annular defects. He also states that some peripheral contraction is the rule. In elaborating on the field defect of acute retrobulbar neuritis, Duke-Elder [4] says that central or cecocentral defects are commonest, and this is undoubtedly correct. However, he mentions the fact that sector defects are rare, but then says that if the scotoma is large, it may break through to the periphery.

While all the descriptions are, in my opinion, essentially correct, there are no figures to tell us exactly how frequently these defects in the field, other than central, occur and, consequently, how frequently fixation is spared. The general impression is that the paracentral, sectoral, and peripheral defects are rather rare. Thus, in the latest edition of his textbook on perimetry, Traquair [5] showed a field of retrobulbar neuritis with sparing of fixation and retention of 20/20 vision and labeled it as a rare type of field change.

PRESENT STUDY

In recent years, I have continually been aware that the occurrence of these supposedly uncommon defects is not quite as infrequent as is generally believed. For this reason, I have selected 100 consecutive cases of optic neuritis in which I was able to make examination in the office or hospital in order to study this problem. These cases were chosen only because the available clinical material was

4. Duke-Elder [2] p. 2979.

5. Traquair,[1] p. 166.

adequate enough to warant a reasonably safe diagnosis of optic neuritis and, also, because visual field studies were satisfactory enough to permit definite conclusions to be drawn from them. Brain tumor was also ruled out, as far as was clinically possible, in the bilateral cases. In case of reasonable doubt of the diagnosis of optic neuritis, the material was not included in this study. It is to be noted that in those cases in which follow-up study was available the earliest defect found was used. Furthermore, in those cases in which multiple attacks occurred only the initial attack was described, and subsequent attacks were not utilized as separate cases, nor were they utilized as a study in fields, inasmuch as they may well have represented cumulative effects.[6] It should also be noted that in some of the cases in which nerve fiber bundle defects were found, with no involvement of fixation, it may well have been that at the very onset of the attack fixation was involved to some

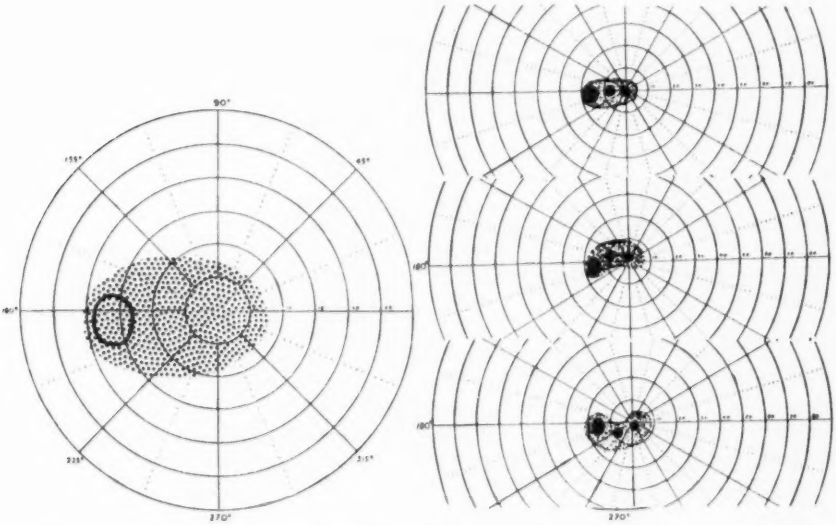


Fig. 1 (Group 1).—Schematic sketch of typical cecocentral scotoma involving fixation (52 cases). The three smaller figures show the variations of the particular nerve fiber bundles involved.

extent, but that this was only of a secondary nature and cleared within a few days after the onset, leaving the denser paracentral defects, which were the more significant ones.

Before presentation of the data as to the visual field defects found, it is pertinent to discuss another factor—the etiology of the optic neuritis. In the first place, the cases were selected on the basis of the diagnosis of optic neuritis, without any regard to etiology. As a matter of fact, no etiological factor was established in most of the cases. While the diagnosis of multiple sclerosis was quite definite in a number of these cases, it would really be unfair to mention this number, inasmuch as many of the patients were seen during an initial attack of retrobulbar neuritis or papillitis,

6. The term "percentage" always refers to the actual number of cases in this paper, since exactly 100 cases are reported.

without any other abnormal findings, but were not seen again. Such patients were usually seen in consultation and had no previous history of disseminated disease. Certainly, it would be hazardous to make a diagnosis of multiple sclerosis in all such cases. On the other hand, it was quite likely that the diagnosis would have applied to many more of the cases if they could have been followed for several years. Another important aspect of the data as presented here is the fact that the patients were seen in various stages of the disease. This should be borne in mind in evaluating the data of this paper. This point will be referred to later.

The visual field defects found were divided into five classes: (1) cecocentral defects; (2) paracentral nerve fiber bundle defects; (3) paracentral nerve fiber bundle defects reaching to the periphery; (4) nerve fiber bundle defects involving fixation and periphery, and (5) peripheral defects only.

Group 1. (Fig. 1).—*Cecocentral defects* (52 cases).

In this category, those cases were considered in which the cecocentral area was involved, with definite encroachment on fixation and marked loss of visual acuity. The maculopapillary bundle particularly was involved, very often with dense nuclei within the cecocentral scotoma. While in most cases the maculopapillary bundle proper was involved, in some of them there was a greater involvement of the nerve

Table 1.—*Fundoscopic Appearance in Group 1 (Cecocentral Defects Only)*

Funduscopic Picture		No. of Cases
Seen at onset	Papillitis	16
	Retrobulbar neuritis	15
Secondary optic atrophy		3
Doubtful		18
Total		52

fiber bundles directly above the horizontal, and in others, directly below the horizontal, as seen in Figure 1. However, there is no significant difference among them, inasmuch as all of them involved fixation to a similar degree. Of the 52 patients, 31 either were seen at the onset of the disease or had a completely reliable history of examination by a competent ophthalmologist, so that it was known that 16 of them had frank papillitis and 14 had retrobulbar neuritis (Table 1). Of the remaining 21 patients, 3 showed rather definite evidence of secondary optic atrophy, while in 18 it was difficult to establish whether the optic atrophy was primary or secondary. It would seem that the important point is that central involvement was present as often in cases of frank papillitis as in cases of retrobulbar neuritis. This would be a point against using the term "retrobulbar neuritis" to denote a central scotoma, since such usage might give the impression that papillitis is not apt to produce a central scotoma as well.

While this category included those cases which showed cecocentral defects only, with normal peripheral vision, I also included here those cases which showed mild peripheral contraction at the onset only, with rapid clearing of the periphery within the first few days, long before any central clearing. When the peripheral defect was of a dense nature and persisted, the case was not included in this category, but in Group 4.

At this time, it will be well to discuss further the terms "central" and "cecocentral." It should be pointed out that all these defects were cecocentral in the

sense that none of them showed a discrete central scotoma limited to the fixation area, without reaching to the blind-spot area. While there may have been dense nuclei within the cecocentral area, as in Figure 6.1, at no time was a distinct, small central defect found with a completely intact cecocentral area, except, perhaps, in the recovery stage, when such a dense nucleus might remain as a relative defect, with clearing of the rest of the cecocentral bridge. However, at the onset no cases were found in which there was a small central defect completely independent of the area caeca. As a matter of fact, it has been my experience that if at the onset of an attack of blurred vision such a small defect is found which reaches out not more than 2 or 3 degrees from fixation, with no field defect between it and the blind spot, it is well to examine the macular area carefully for lesions such as

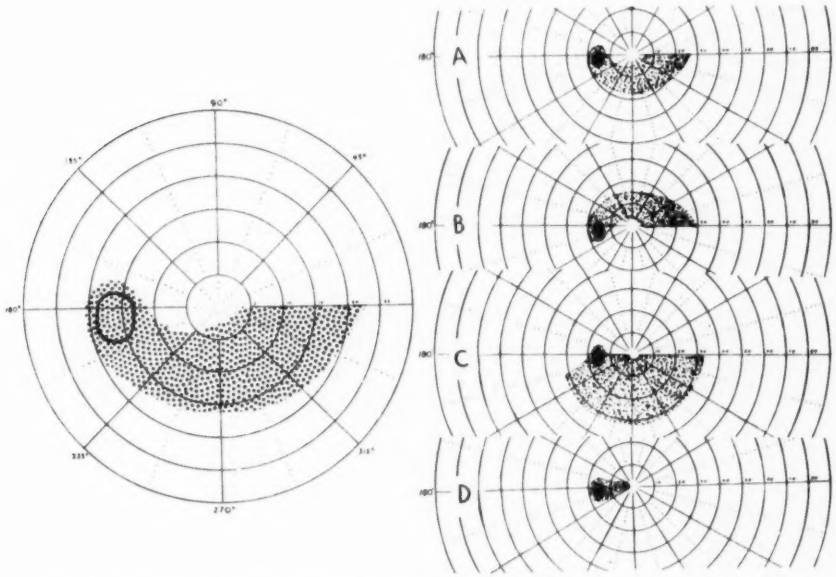


Fig. 2 (Group 2).—Typical paracentral nerve fiber bundle defect (schematic), sparing fixation (24 cases), in order of frequency: *A*, defect mostly below fixation and nasally, 6 cases; *B*, defect mostly above fixation and nasally, 5 cases; *C*, defect below fixation, 3 cases; *D*, defect mostly "cecoparacentral" (not quite reaching fixation), 5 cases (example in Figure 6.1).

angiospastic retinopathy, or other small macular lesions, rather than make a diagnosis of retrobulbar neuritis.

In summary, 52 cases showed cecocentral scotomas with involvement of central visual acuity and a relatively intact peripheral field.

Group 2 (Fig. 2).—*Paracentral nerve fiber bundle defects* (24 cases).

In this category, only those cases were included which showed a typical nerve fiber bundle defect starting at the blind spot and skirting around fixation, but sparing the latter, and ending in the region of the horizontal raphe, on the nasal side (Fig. 2). In each of these cases there was an outer limit of the defect, with a good field beyond it, so that the periphery was intact. Twenty-four such cases

were found. In 19 of these the data were sufficiently good to indicate where most of the defects were found. This will be seen in Figure 2, as well as in Table 2, which shows that the greatest part of the nerve fiber bundle defect occurred in the lower nasal field in six cases, in the upper nasal field in five cases, and in the lower field in three cases. In five other cases the defect was what I have termed a "ceco-paracentral" scotoma, indicating that there was a horizontal defect extending from the blind spot toward fixation, but not quite reaching it. It is this type of scotoma which may offer a challenge to inexperienced observers, in that the patient is well able to read the 20/20 line, thus giving the impression that the central field is

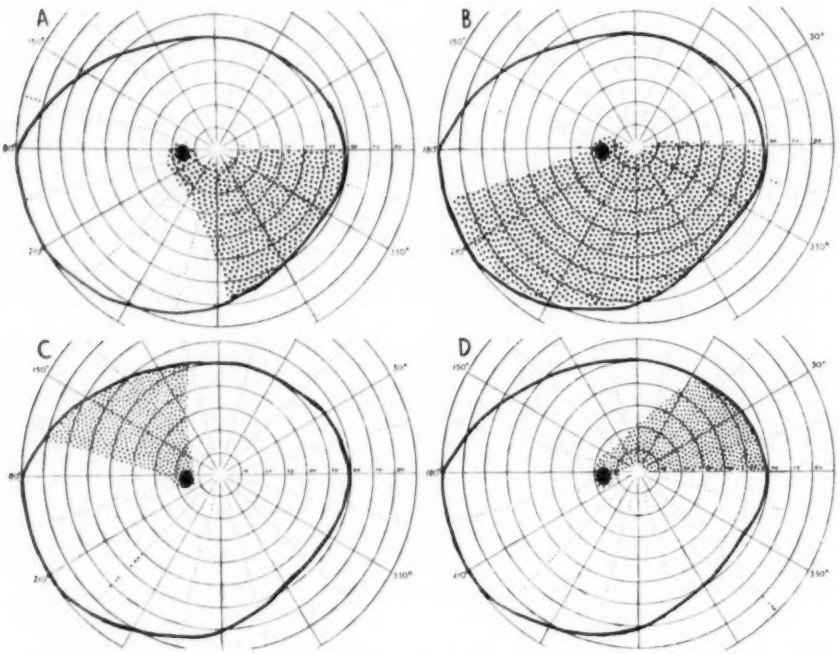


Fig. 3 (Group 3).—Distribution of paracentral field defects (schematic), sparing fixation but breaking through to the periphery (nine cases), in order of frequency: *A*, lower nasal, 4 cases; *B*, lower, 3 cases; *C*, upper temporal periphery, 1 case; *D*, upper nasal periphery, 1 case.

intact. In some cases the patient merely complains of a slight blurring of this line, and in other cases there may actually be a very slight extension of this blur, causing vision to diminish to 20/30, or so, but the dense portion of the scotoma, which is the most significant part, is actually paracentral and spares fixation. Such a case is that of B. F. (Fig. 6*B*).

Group 3 (Fig. 3).—*Nerve fiber bundle defects extending to periphery* (9 cases).

In this category are included those cases which showed nerve fiber bundle defects that were paracentral but, instead of remaining wholly within the central field, also extended out and broke through the periphery, as in Figure 7*A*. However, they were similar to those in Category 2 in that fixation was spared, or practically spared.

Nine such cases were found. The break-through of the defect to the periphery may well offer a problem in diagnosis in some cases, in that it may simulate the field defect caused by a mass lesion around the region of the optic foramen. Thus, in such cases in which there is a poor history as to the mode of onset and it is difficult to determine whether the optic atrophy is primary or secondary, a peripheral defect extending to the paracentral area may simulate the defect caused by a mass lesion. Again, it is noted in Figure 3 and in Table 2 that the break-through occurred most frequently in the lower nasal area (four cases), and next most frequently in the entire lower periphery (three cases). The upper temporal area and upper nasal area were involved in only one case each.

In Groups 2 and 3, in both of which fixation was spared and which comprised a total of 33 cases, there was definite evidence of papillitis in 13 cases. Of these cases, 12 were seen at the onset, and the sparing of fixation was definite. Eight cases showed definite evidence of retrobulbar neuritis. Of these eight cases, six were actually seen at the onset. In 6 of the remaining 12 cases there was definite evidence of secondary optic atrophy, while in the remaining 6 cases the type of atrophy was not typically primary or secondary in appearance.

TABLE 2.—*Distribution of Paracentral and Peripheral Field Defects in Optic Neuritis*

	Lower Nasal	Lower	Upper Nasal	Cecopara-central	Upper Temporal	Lower Temporal	Entire Periphery	Unknown	
Group 2, paracentral nerve fiber bundle defects	6	3	5	5	..	..	..	5	24
Group 3, paracentral nerve fiber bundle defects reaching to periphery	4	3	1	..	1	..	..	..	9
Group 4, nerve fiber bundle defects involving fixation and periphery	5	4	..	..	..	1	1	..	11
Group 5, peripheral defects only...	1	2	..	..	..	..	1	..	4
	16	12	6	5	1	1	2	5	48

On evaluation of the above data, it is apparent that in both types of cases, that is, those of papillitis and those of retrobulbar neuritis, nerve fiber bundle defects may be produced which spare fixation, although it happened more frequently in papillitis than in retrobulbar neuritis (12 as compared with 6 cases), if one considers only those cases which were seen at the onset. If one were to consider the six cases that showed definite secondary optic atrophy as those of past episodes of papillitis, then one might increase the 12 cases to 18 and say that sparing of fixation may occur three times as frequently in cases of papillitis as it does in cases of retrobulbar neuritis (18:6). However, it has been my experience that even after a true retrobulbar neuritis, when atrophy sets in, it is apt to be of a secondary, rather than a primary, type. In other words, there are very often some fuzzing of the edges and a slight filling in of the physiological cup, perhaps with some clouding over of the lamina cribrosa. Thus, a pure "primary" optic atrophy is very uncommon in the ordinary variety of retrobulbar neuritis, and it is therefore quite likely that most of these cases of retrobulbar neuritis harbor the lesion very close to the papilla. It would, therefore, be rather difficult for me to believe that there is a sharp anatomical delineation between pure papillitis and pure retrobulbar neuritis, and that true papillitis is more apt to cause defects that spare fixation. However, this is a possibility.

Group 4 (Fig. 4).—*Nerve fiber bundle defects involving fixation and periphery.*

This category included 11 cases, all of which showed extensive nerve fiber bundle defects involving fixation and reaching out to the periphery as well, as in Figure 7*B*. It is apparent from Table 2 that in five of these cases the defect extended to the lower nasal periphery, and in four of them to the entire lower periphery. In only one case was the lower temporal periphery involved, while in a single other case, that of M. B., the entire field was involved. This was probably a case of Devic's disease, with transverse myelitis and a history of loss of vision in the left eye some time back, and then very little recovery. This was followed

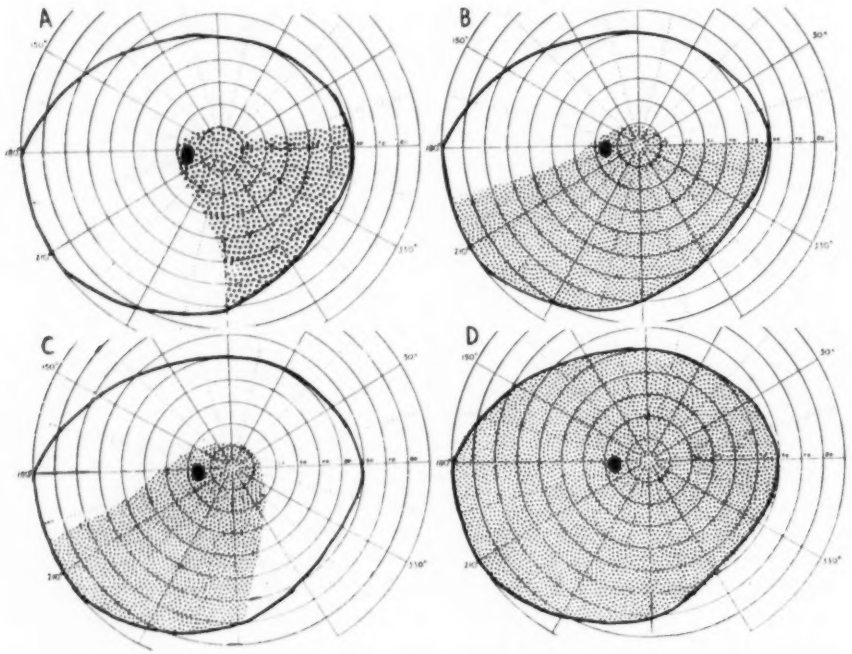


Fig. 4 (Group 4).—Nerve fiber bundle defects (all schematic) involving fixation and breaking through to the periphery (11 cases), in order of frequency: *A*, lower nasal field, 5 cases; *B*, entire lower field, 4 cases; *C*, lower temporal field only, 1 case; *D*, entire periphery, 1 case.

by retrobulbar neuritis in the right eye, with a good deal of recovery. Recently, a second attack took place in the right eye, involving either the remaining portion of the nerve or the entire optic nerve at the same time. This strongly resembled a transverse neuritis, or perhaps a cumulative effect of two attacks. In any event, the eye was completely blind. I stress this case because it is the only one I found in the entire series in which there was complete loss of vision, without even light perception. It has been my experience that such a case is rare in optic neuritis, and this was also the observation in a series of 600 cases reported by Sarbo.[7]

7. von Sarbo, A.: Zur Aetiologie der retrobulbären Neuritis vom neurologischen Standpunkt, Klin. Monatstbl. Augenh. **88**:762, 1932.

GROUP 5 (Fig. 5).—*Peripheral defects.*

This category primarily included cases of peripheral defects, and four such cases were found. In one, there was severe involvement of the entire periphery, with preservation of a small central field with 20/20 vision. Beyond the fact that there was optic atrophy, very little else could be found out about the case. However, there was good clinical evidence that the lesion was inflammatory and that no further progress took place over a long period. In still another case (R. L.) there was a peripheral defect only, without any connection whatever with the blind spot (Fig. 8*A*). At no time did the defect approach the fixation point closer than 12 degrees, and the patient was followed carefully for a year and a half, at the end of which time pneumoencephalography showed no evidence of an intracranial mass. This is the only case in this series in which a peripheral defect was completely isolated from the central field and in no way connected with the area caeca. It is probably an

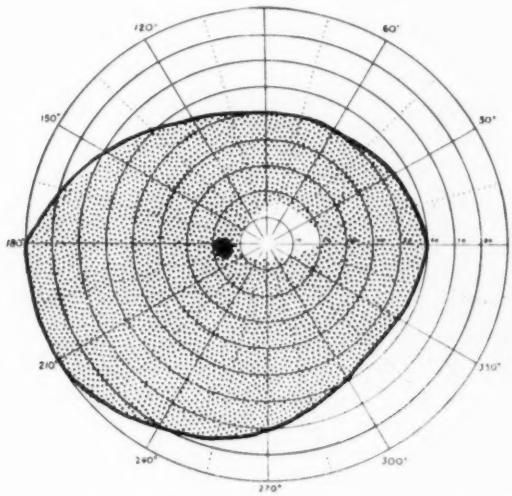


Fig. 5. (Group 5).—Peripheral defect only (4 cases; all schematic). Most of the periphery was involved in three cases. One case (R. L.; Fig. 8*A*) showed only a peripheral lower nasal defect, with no connection to the area caeca.

instance of true periaxial neuritis. Finally, the two remaining cases concerned the eyes of one person (H. K.), in whom the onset was rather abrupt and accompanied by severe papillitis. The field defect was largely that of a marked peripheral contraction, affecting some portions of the periphery more than others, but with no serious encroachment on fixation. As a matter of fact, after the first day or two, the patient was well able to read 20/30, which seemed to be his best central visual acuity at any time.

This case offered special interest and probably comes under the classification of so-called "perineuritis optica." It involved a man aged 55, first seen in August, 1951. At the time of the first examination he had a two week history of sudden onset of blurring of vision in his left eye. Visual acuity was 20/30—2 in the left eye and 20/20 in the right eye. Examination revealed definite papilledema of both nerve

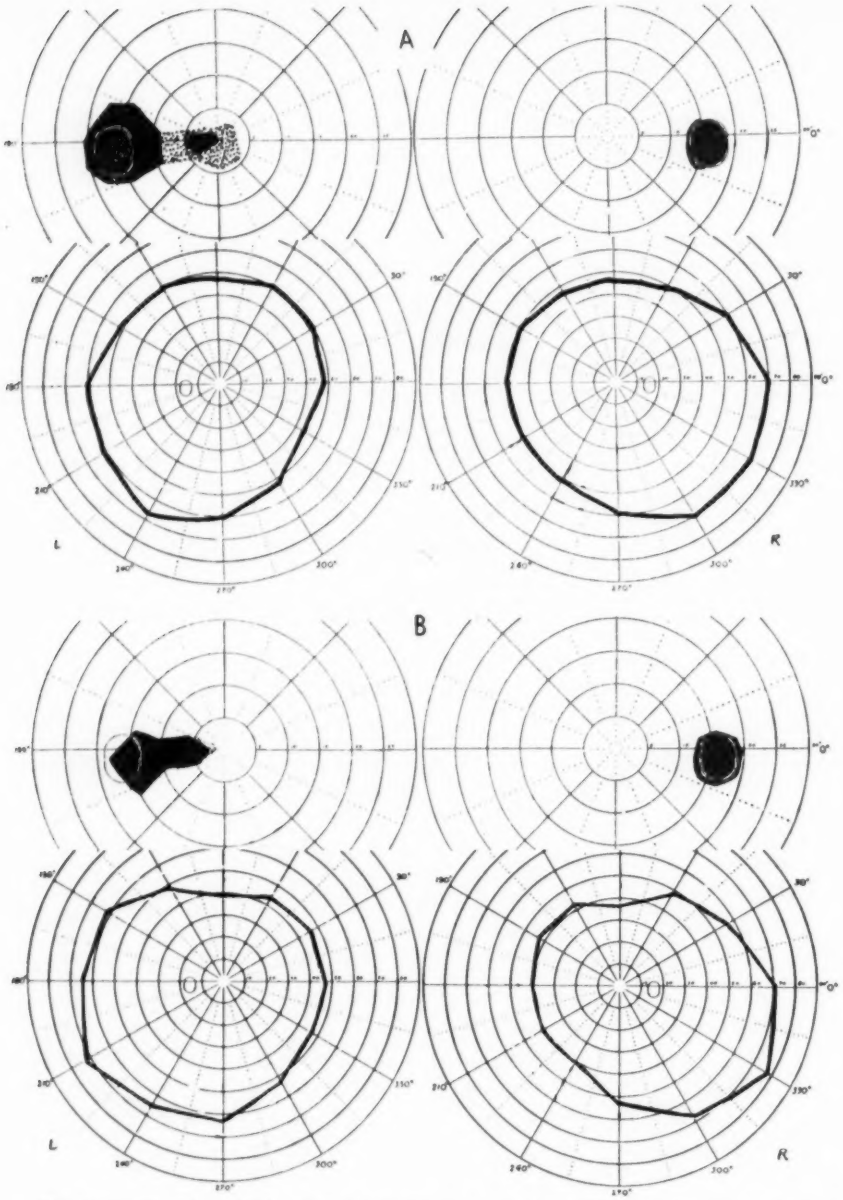


Fig. 6.—*A* (E. C.) papillitis of the eye in a young man, showing relative cecocentral scotoma for 5/2,000 white, with dense paracentral nucleus. Vision: R. E.: 20/20; L. E.: 5/100. The periphery was almost normal for 2/330 white.

B (B. F.), fields for a woman aged 31 with a history of sudden blurring of vision in the left eye for several days. The patient had myopia, and vision was correctible to 20/25 in each eye, with glasses. Peripheral fields for 2/250 white were normal. The left central field for 2/2,000 white showed a "cecoparacentral" defect, extending to, but not quite reaching, fixation. Clearing was spontaneous in about 19 days. Six months later nystagmus and other signs of disseminated sclerosis developed.

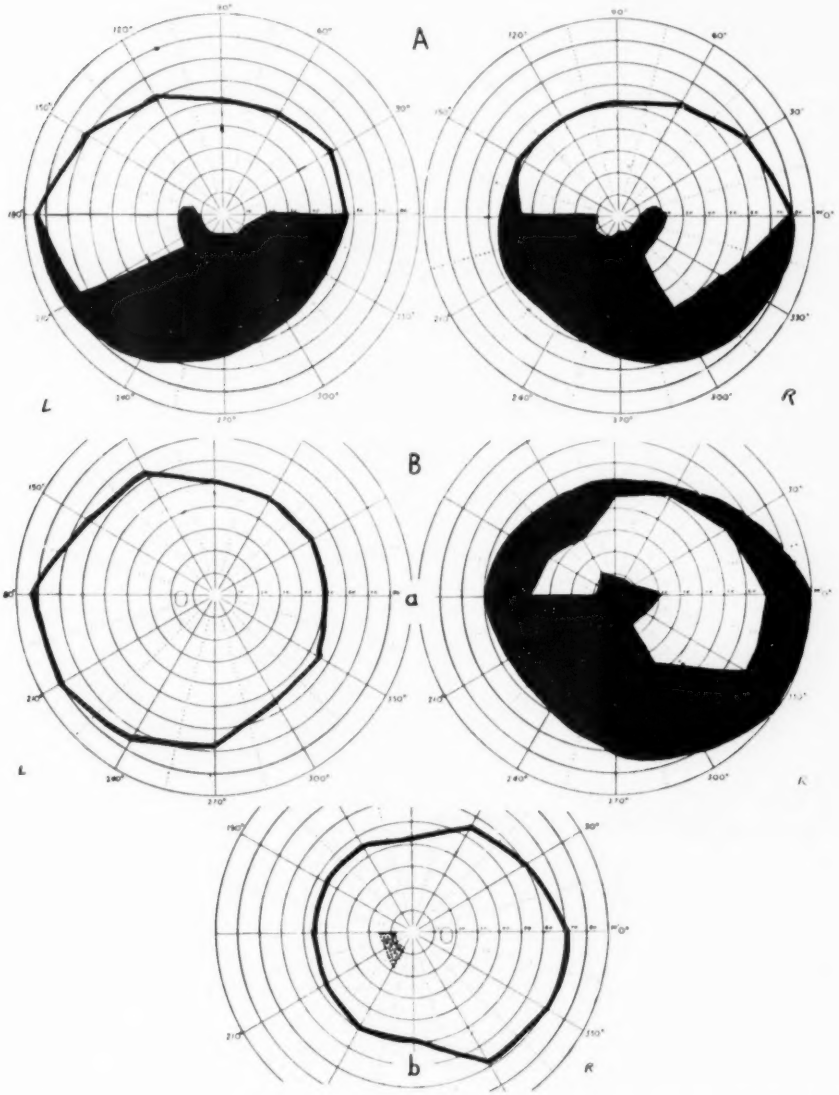


Fig. 7.—*A* (M. N.), paracentral nerve fiber bundle defects, sparing fixation, but breaking through to the periphery, in a case of postneuritic atrophy in the right eye and papillitis in the left eye in a man aged 48. Fields were examined with 2/250 white. Vision: R. E.: 20/30; L. E.: 20/20.

B (I. K.): (*a*) Acute papillitis in the right eye in a young man. Vision: R. E.: hand movements; L. E.: 20/15. Fields are for 5/250 white (right eye) and for 2/250 white (left eye).

(*b*) Eighteen days later. Vision in the right eye had returned to 20/20—2, and the field for 1/250 white showed only a slight residual paracentral defect.

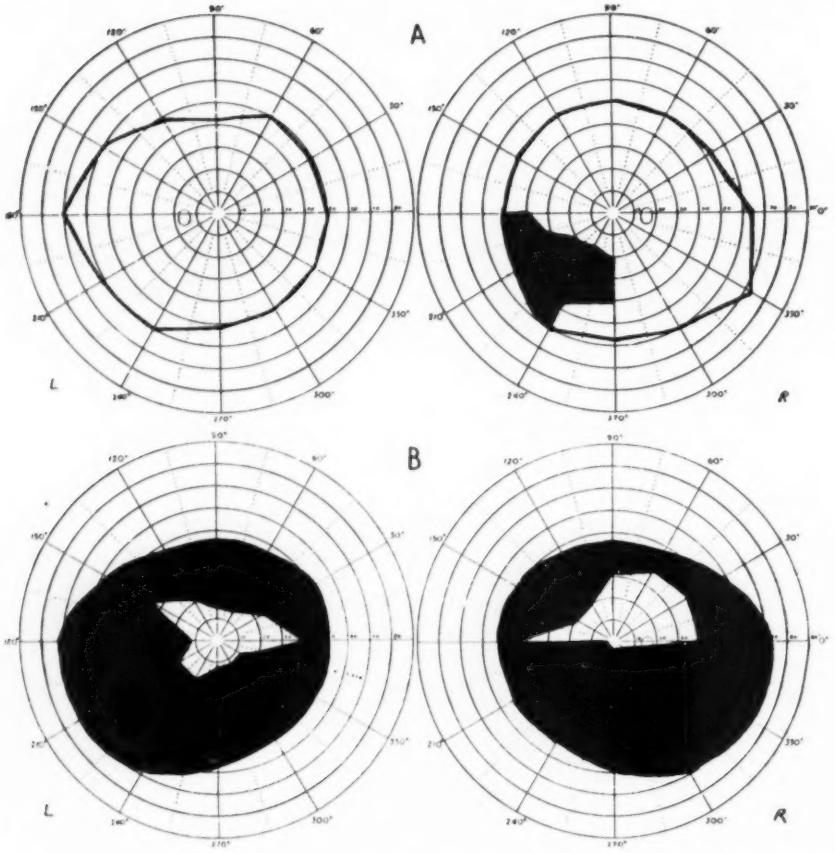


Fig. 8.—*A* (R. L.), fields for a 23-year-old white woman with a history of sudden blur in the lower nasal field of the right eye. Peripheral fields for 1/330 white showed a contraction in the lower nasal field of the right eye. Central field studies showed essentially the same changes, with no perceptible connection of the defective area to the blind spot, regardless of the test object used. Complete neurological investigation showed no evidence of intracranial disease. There was little or no recovery, but slight optic atrophy set in, and, after 18 months of follow-up study, pneumoencephalography showed no evidence of intracranial disease and the diagnosis of retrobulbar neuritis was considered in order.

The appearance of pallor was rather dubious. This may possibly be explained on the basis of what is believed to be the distribution of fibers on the nerve head. Thus, since macular fibers occupy most of the area of the disc on the temporal side (wherefore central scotomas produce temporal pallor), the fibers from all the periphery are concentrated in the small nasal portion of the disc. Therefore, it is not surprising that when only a small portion of the peripheral fibers is defective, the optic atrophy may be too inconspicuous to be recognized as such.

B (H. K.), perineuritis optica in man aged 55. See text (last case in Group 5). Fields are for 2/250 white at the time of the attack in the second eye. Vision: R. E.: 20/20: L. E. 20/30—2.

heads, with complete blurring of all margins and absence of any physiological cups. There were no venous pulsations. This fundoscopic picture was bilateral, although the patient had no complaints whatever about his right eye. Visual field studies revealed a marked peripheral contraction in the field of vision of the left eye, with some encroachment on the central area, but to a much less extent than in the periphery. The peripheral encroachment was such that the area caeca was included within the scotomatous area. In the right eye the only finding of note was the marked enlargement of the blind spot, in keeping with the edema of the nerve head.

A complete neurological investigation, including electroencephalography, was made. The only significant finding was that of the spinal puncture, which revealed an initial pressure of 260 mm. of water. The protein was 60 mg. per 100 cc., and there were no cells. Because of the increased intracranial pressure, a ventriculogram was made. It revealed the ventricular system to be entirely normal. The neurosurgeons reported that when the burr holes were made, there was a tremendous escape of subarachnoid fluid, much as is seen in so-called "serous meningitis." For this reason, a subtemporal decompression was offered to the patient, but he refused the procedure. Instead, spinal punctures were repeated daily for several days; but after the initial ventriculographic examination the spinal pressure was always found to be within completely normal limits, despite the fact that no subtemporal decompression was performed. After several days, when the spinal fluid pressure was still normal, the patient was discharged. However, the marked peripheral contraction in the left field still persisted, the defective area lying mostly below, but involving, the entire peripheral field. In its encroachment on fixation, the nasal field particularly was invoved, but fixation proper was spared, so that visual acuity remained at 20/30—1. The papilledema in both eyes subsided within several weeks after the initial studies were made; and, while the right disc reassumed an almost normal appearance, the left disc showed signs of secondary optic atrophy.

No further change was noted in this patient, although he was watched carefully from time to time between September, 1951, and November, 1952, when he came in with a history very similar to the one of a year before. On Nov. 12, 1952, he gave a two-week history of sudden blurring of vision in the right eye. His visual fields at this time are shown in Figure 8*B*. Examination revealed marked swelling of the right optic nerve head, together with several hemorrhages. In the left fundus, the discs continued to show signs of postneuritic optic atrophy, with no cup and no venous pulsations. Visual acuity remained 20/30—1 in the left eye, and remained 20/20—1 in the right eye, indicating no encroachment on fixation. Visual field studies revealed that, while there had been no further change in the status of the left eye, there was then in the right eye a marked peripheral contraction, involving particularly the lower field, with encroachment on, but not quite reaching, fixation. All serological tests performed on the blood and spinal fluid for specific disease were negative.

In view of the sudden onset of blurring of vision, involving the periphery especially, and the visible papillitis, it is believed that this case represents one of perineuritis optica, with extension to and involvement of the periphery of the nerve trunk (periaxial neuritis) as well. Certainly, this is not a frequent occurrence; and when it is accompanied by some increase in intracranial pressure,[8] as in this

8. Such cases of perineuritis optica with increased intracranial pressure are described by Walsh,[3] page 358.

case, it may be most difficult to differentiate from increased intracranial pressure due to other causes. When such a cause is an intracranial tumor, an air study is usually sufficient to exclude it. On the other hand, if this case were truly one of so-called "serous meningitis" (otitic hydrocephalus; pseudotumor cerebri), while the ventriculographic findings would appear identical with the ones found in this case, that is, a normal ventricular system, the clinical picture, on the other hand, would not have been accompanied by a sudden, rapid onset of profound loss of peripheral vision in one eye, as was found here. Furthermore, if this condition were serous meningitis, it is most unlikely that the spinal fluid pressure would immediately become normal and remain so after the initial burr holes were made.

It should be noted at this point that in Group 2 (24 cases), Group 3 (9 cases), and Group 5 (4 cases), a total of 37 cases, there was sparing of fixation with preservation of good central visual acuity (Snellen). From this, one might postulate that 37% of the cases of optic neuritis show normal central visual acuity! However, one must allow for the fact that only 21 of these were seen at the onset of the attack; so we may vouch for that many only (18 cases in Groups 2 and 3 and 3 cases in Group 5). Nevertheless, even 21% means that at least one out of five cases of optic neuritis may be expected to show sparing of fixation with normal or nearly normal visual acuity, and thus could hardly be considered "rare."

COMMENT

The foregoing figures show that the marked peripheral defects (Groups 3, 4, and 5) occurred in 24 cases. These peripheral defects were not secondary to a denser central defect, but were actually the densest portion of the scotoma. Certainly a peripheral defect of this sort cannot be considered rare when it may occur in one out of four cases. It is unfortunate that the neuro-ophthalmologist should find so high an incidence of peripheral involvement in optic neuritis, because it makes the differentiation from field defects due to mass encroachment a more difficult problem.

As for the preservation of central visual acuity, the finding of normal, or nearly normal, central visual acuity in at least 21% of the cases, and possibly as high as 37%, must be recognized by the ophthalmologist as an important phenomena, and it bears out the great importance of careful visual field studies in differentiating optic neuritis and papilledema. Of course, in these cases of sparing of fixation, the patient will very easily recognize small colored test objects centrally, and therefore such rough testing as recognition of color centrally is most inadequate in excluding optic neuritis and arriving at a diagnosis of papilledema. Such a test, therefore, is not to be relied upon and must be replaced by accurate and full visual field studies.

It is also quite likely that this rather high incidence of preservation of good central visual acuity may well account for the fact that many cases of retrobulbar neuritis occur but are unnoticed by the patient.[9] This is especially true when the patient may be having other symptoms of systemic disease, such as multiple sclerosis,

9. This concept is borne out by two of my colleagues at Montefiore Hospital. Dr. Samuel Gartner found histopathologic evidence of optic neuritis in each of 10 cases of multiple sclerosis verified by autopsy. In only 6 of the 10 cases was the visual defect known to exist during life. Similarly, Dr. Abraham Schlossman and Dr. Carleton C. Phillips, in carrying out a concomitant study of optic neuritis in multiple sclerosis, found that of 57 patients with definite optic atrophy only 47 had a history of loss of vision, the other 10 patients being completely unaware of it.

and is perhaps too sick to notice that there is a little blurring in the periphery of the field. It is probably in cases such as these that examination reveals a definite temporal pallor with a residual field defect of some sort, indicating that there was retrobulbar neuritis, but no definite history of an episode of visual loss can be obtained from the patient. Very likely, in these cases the patient did not lose central visual acuity at any time, and therefore was not aware of the acute attack at the time it occurred. It is also my impression that the casual recognition of such cases by the examiner, and perhaps the patient's greater awareness of such defect only when he is systemically better able to recognize it, may falsely lead one to believe that the attack is low-grade and chronic in nature, and therefore results in such diagnoses as "chronic" retrobulbar neuritis. I cannot say that I have found good clinical evidence to substantiate such a diagnosis in any of the patients I have ever examined.

As for the greater involvement of the nasal side of the field, both paracentrally and in the periphery, I do not believe that this is clinically important, inasmuch as the nasal field is more vulnerable in other conditions, such as glaucoma, and even in the field defect as found in postpapilledema states; there may be some explanation of this, based on the anatomical distribution of the corresponding fibers in the disc area and just behind it.

SUMMARY

Visual field studies are presented in 100 cases of optic neuritis (papillitis and retrobulbar neuritis).

The cecocentral scotoma with a relatively intact periphery was found in 52% of the cases, and probably occurs with equal frequency in papillitis and in retrobulbar neuritis.

The periphery was definitely involved in 24% of the cases (Groups 3, 4, and 5). In only one case (R. L.; Group 5; Fig. 8*A*) was an isolated peripheral defect found which had no connection with the area caeca, and this case may possibly be considered one of periaxial neuritis.

In cases of paracentral and peripheral involvement of the field, the area most frequently involved was the lower field, particularly the lower nasal field.

The fixation point, and therefore central visual acuity, was spared in 37% of the cases (Groups 2, 3, and 5). Of these 37 cases, 21 were seen at the onset of the disease, so that one may safely say that certainly in at least 21% of the cases of optic neuritis central visual acuity is maintained. This is corroborative evidence that the preservation of central visual acuity alone must not be used as a major criterion for differentiating optic neuritis from other conditions, such as papilledema.

RECONSTRUCTION OF THE ORBIT WITH POLYVINYL SPONGE

Report of a Case

JOHN W. HENDERSON, M.D.
ROCHESTER, MINN.

WITH THE continued frequency of fractures of the face and orbit as the result of accidents in both civilian and military states, plastic and ophthalmic surgeons are on the lookout for materials and methods that will improve the results of facial and orbital reconstruction and that also will be practical to apply.

For many years the chief materials used in reconstructive operations of this type have been bone and cartilage. These substances are still widely used, but, because of the difficulties of obtaining, cutting, and molding them, many attempts have been made to replace them with nonliving foreign materials. Most of these materials were created as the result of the emphasis on reconstructive operations that came about during and after World War II. Although many of the materials were practical in application, they had one great disadvantage as compared with bone and cartilage—they were not viable and behaved as foreign bodies in the tissues into which they were inserted.

Among the plastic materials that have been described in the past several years, there has been one that, because of its tendency to become an integral part of the tissues into which it is transplanted, seems more promising than others for reconstructive purposes. This plastic material is prepared from polyvinyl alcohol and has been used both experimentally and clinically in various surgical fields by Grindlay and Clagett,[1] Grindlay and Waugh,[2] and Love and Dodge.[3]

Polyvinyl, in the form of a sponge, is made by foaming polyvinyl alcohol and then hardening the substance with formaldehyde. Grindlay and Waugh [2] have given an excellent description of many of the physical and chemical properties of this sponge. Briefly, in its pure state, it is white and has a texture resembling bread. When moist, the sponge is elastic and soft and can be trimmed with scissors; when dry, it is hard and rigid and is best cut with a knife or saw. It is an extremely light substance and does not possess any odor or taste. It is unaffected by most chemicals at ordinary temperatures except strong acids and alkalies and dilutions of alcohol

From the Section of Ophthalmology, Mayo Clinic.

1. Grindlay, J. H., and Clagett, O. T.: A Plastic Sponge Prosthesis for Use After Pneumonectomy: Preliminary Report of an Experimental Study, Proc. Staff Meet., Mayo Clin. **24**:538-539 (Oct. 12) 1949.

2. Grindlay, J. H., and Waugh, J. M.: Plastic Sponge Which Acts as a Framework for Living Tissue: Experimental Studies and Preliminary Report of Use to Reinforce Abdominal Aneurysms, A. M. A. Arch. Surg. **63**:288-297 (Sept.) 1951.

3. Love, J. G., and Dodge, H. W., Jr.: Transcranial Removal of Intra-orbital Tumors, unpublished data; Use of Polyvinyl Plastic Sponge in Neurosurgery, unpublished data.

between 30 and 70%. It may be sterilized by boiling for 30 minutes and then cooled with water, but when boiled it is prone to mold itself to the shape of the container. For this reason it is usually preferable to sterilize the sponge by one of the "cold" methods. The sponge has an affinity for water equal to that of sea sponge. Because of this characteristic, the sponge is manufactured for many commercial purposes.

One of the most interesting features of this sponge is the tendency for the interstices to be filled with a noninflammatory fibrous tissue when the sponge is embedded in tissue. Because of the reasonable possibility that the sponge would become an integral part of the tissues with which it was in contact and because of its inertness, elasticity, and pliability when wet, its use in a reconstructive problem involving the orbit was suggested. The report of a case in which the sponge was used to restore the appearance of an orbit seems worth while.

REPORT OF CASE

A 10-year-old boy fell from a haymow on June 26, 1950. The total distance of the fall was estimated to be 15 ft. (4.5 meters). Roentgenograms of the head revealed a comminuted fracture of the right frontosphenoidal region laterally, with depression of the sphenoidal fragment. The fracture extended across the floor of the anterior fossa, involving the roof of the right orbit. The initial clinical inspection showed the right eye to be proptosed and divergent. Incomplete

Fig. 1.—Preoperative appearance.

external ophthalmoplegia seemed to be present. Extensive ecchymosis of the eyelids and a hematoma of the right frontal area were present. An attempt was not made to reduce the fracture of the orbit because of the poor condition of the child. With conservative care, the proptosis of the eye, the hematoma, and the ecchymosis subsided.

The child was next seen almost six months later, on Dec. 18. At this time he complained of diplopia. The right eye was divergent about 40△ as measured with fixation on a target at a distance of 6 meters. The eye and the entire orbital contents on the right side were approximately 5 mm. lower than the structures in the left orbit (Fig. 1). Proptosis or enophthalmos of the right eye had not occurred. Visual acuity was normal. Ophthalmoscopic examination did not reveal any abnormality. The upper eyelid did not droop, and the position of the fold in the upper eyelid was not abnormal. It was deemed best to attempt correction of the ptosis of the orbital contents on the right side and of the deviation of the eye. This was done in two stages.

On Dec. 27 an incision was made through the skin, orbicularis oculi, subcutaneous tissue, and orbital septum of the right lower eyelid. This incision was made roughly parallel to the inferior margin of the orbit. With blunt dissection, a pocket was created between the periorbita and the orbital fat along the floor of the orbit. An attempt was not made to incise the periorbita or to expose the bone in any way. Into the pocket a triangular piece of polyvinyl sponge was placed. The apex of this piece of sponge was placed so as to approach the apex of the orbit, and the base was placed so as to lie just behind the inferior orbital margin. The sponge measured 30 mm. along both the base and the nasal edges and about 40 mm. along its

temporal face. It was about 10 mm. thick. The sponge was not sutured to any tissue. When the sponge was in position, it seemed to produce a reasonably satisfactory elevation of the eyeball and soft tissues of the orbit. I hesitated to insert a larger piece of polyvinyl sponge for fear of producing proptosis. The incision was closed with interrupted absorbable surgical (catgut) sutures through the tissues beneath the skin and with interrupted nonabsorbable surgical (silk) sutures in the skin proper. A light pressure dressing was applied.

The child's convalescence was uneventful. The skin sutures were removed and the child allowed to resume school on the 10th postoperative day.

The child was seen next on July 7, 1951. The divergence of the eye had not been appreciably altered by the previous operation, as the deviation then measured about 30△. The appearance of the right orbit, however, was definitely improved. The contents of the right orbit seemed to be only 1 mm. lower than similar structures on the left side. The vertical diameters of the palpebral apertures were equal on the two sides, indicating that enophthalmos was not present. The exophthalmometric measurements also were equal. Neither the lower eyelid

Fig. 2.—Appearance of eyes six months after implantation of polyvinyl sponge in right orbit and one week after correction of divergent strabismus of right eye.

Fig. 3.—Appearance of eyes two years after implantation of polyvinyl sponge in right orbit.

nor the inferior conjunctival fornix was abnormal, indicating that adhesions had not formed between these tissues and the sponge implant. Vision in the right eye was normal, and, again, an ophthalmoscopic examination did not reveal any abnormality.

On July 10, 1951, the strabismus was corrected by resection of the right medial rectus and recession of the right lateral rectus (Fig. 2).

Another examination of the status of the right orbit and right eye was performed on Dec. 22, 1952, two years after the implantation of the polyvinyl sponge. It was found that the child was suppressing the vision in the right eye, and a divergent strabismus, of 25△ at a fixation distance of 6 meters, was again present. The position of the eye in relation to the surrounding orbital contents, however, seemed unchanged from that noted in the previous examination. The ocular rotations were not limited; neither exophthalmos nor enophthalmos was present. The orbital contents on the right side still seemed about 1 mm. lower than similar structures on the left side, a finding similar to that noted on July 7, 1951. Except for the divergence of the right eye, the parents of the patient seemed pleased with the appearance of the face and orbit (Fig. 3).

COMMENT

In the period of more than two years that this child has been under observation, no indication of intolerance of the orbital tissues to the plastic sponge implant has occurred. The surgical incision in the right lower eyelid healed promptly. If the position of the globe can be used as a criterion, any evidence that the sponge had migrated from its original position was absent. By the same token, significant shrinkage or expansion of the implant was absent. All these features attest to the inertness of the polyvinyl sponge.

At the time the plastic material was inserted into the orbit, sutures were not used to anchor it in a particular position or to attach it to the fibrous and muscular adnexa of the globe. Throughout the period of observation the eye has retained its mobility, and neither the globe nor the extraocular muscles seem to have become attached to the sponge by scar tissue. Grindlay and Waugh [2] have pointed out that this material will become fixed to surrounding tissue if sutured to it, but that if sutures are not used, the plastic sponge remains movable, although surrounded by and filled with a noninflammatory fibrous tissue. The behavior of the eye in the present case would bear out this statement, particularly in regard to the freedom of the globe from undesirable adhesions.

A notable factor in this case is the simplicity of the operative procedure. The plastic sponge was easily cut and shaped to fit the pocket created in the orbital fat. I found this much easier than cutting and molding a suitable piece of cartilage or bone. In addition, the cartilage and bone must be inserted beneath the periorbita to assure a blood supply, whereas with this sponge such precautions are unnecessary.

Although more than two years have passed, it is still rather early to say what the ultimate result of use of this foreign material in the orbit may be. On the basis of experimental work,[4] it is likely that there has been a growth of noninflammatory fibrous tissue into the interstices of the sponge, so that it has become incorporated in the mass of soft tissue in the inferior portion of the orbit. Just why the polyvinyl sponge should become a scaffold or framework for living tissue, and thus become an integral part of the surrounding cells, is difficult to explain. Grindlay and Waugh [2] have tried to answer this question by stating:

> The peculiar affinity of polyvinyl sponge for water, which is far more than a surface affinity, and the fact that tissue cells live in a water environment, give the sponge a kinship with living tissue. Perhaps tissue fails to recognize polyvinyl sponge as a foreign body, because tissue fluids enter it. Cells follow fluid, and what was inert becomes living.

My experience with polyvinyl sponge has been sufficiently satisfactory and the progress of this patient during a two-year period of observation is good enough to justify my recommending that this plastic material be given a trial in other reconstructive problems involving the orbit.

4. Grindlay, J. H.: Personal communication to the author.

OPTIC NEUROPATHY IN MULTIPLE SCLEROSIS

Optic Neuritis

SAMUEL GARTNER, M.D.
NEW YORK

THE CLINICAL diagnosis of optic neuritis is frequently made, but histologic studies have been few. This report is based on the microscopic examination of eyes in which the optic nerve was affected in multiple sclerosis and which were studied at autopsy at the Montefiore Hospital.

MULTIPLE SCLEROSIS

Fourteen eyes were obtained from 10 patients for whom the diagnosis of multiple sclerosis was confirmed by the autopsy findings. Of these 10 patients, 4 were men and 6 women. The average age at death was 40.6 years.

Every patient showed some defect either in the eye or in the optic nerve. The shortest interval before death in which a visual defect developed was one year; the longest interval was 7.25 years.

An attack of acute optic neuritis was diagnosed during life in only two patients. Four others gave a history suggestive of an attack of optic neuritis. Two had temporary periods of blurred vision; another "saw through a haze" for a while, and one noted sudden loss of vision, which cleared up after a time.

Of the remaining four, one had vision which could not be improved beyond 20/70 in one eye and 20/40 in the other, and he only stated that poor vision had begun some time before. The second patient had blurred vision in the left temporal field. The third had high myopia (over —20.00 D.). His development of partial blindness was not accounted for during life. The fourth gave no history of visual difficulty, but, unfortunately, I have no record of her visual acuity. However, bitemporal pallor was noted, and the histological examination of the eyes disclosed atrophy of the ganglion cells at the macula and partial optic nerve atrophy.

This group was composed of advanced cases. Although 10 patients is a small number, it nevertheless is interesting that every one showed involvement of the visual pathways. The reports of clinical cases of multiple sclerosis indicate a far lower incidence of optic nerve involvement. Recent reports include those of Bagley,[1] Savitsky and Rangell,[2] Yaskin and associates,[3] Carroll,[4] and Wybar.[5]

From the Eye Laboratory of the Montefiore Hospital for Chronic Diseases.

Presented in part at the New York Society for Clinical Ophthalmology, Jan. 5, 1953.

1. Bagley, C. H.: An Etiologic Study of a Series of Optic Neuropathies, Am. J. Ophth. **35:** 764, 1952.

2. Savitsky, N., and Rangell, L.: The Ocular Findings in Multiple Sclerosis, A. Res. Nerv. & Ment. Dis., Proc. (1948) **28:** 403, 1950.

3. Yaskin, J. C.; Spaeth, E. B., and Verlund, R. J.: Ocular Manifestations of 100 Consecutive Cases of Multiple Sclerosis, Am. J. Ophth, **34:**687, 1951.

4. Carroll, F. D.: Optic Neuritis: A 15-Year Study, Am. J. Ophth. **35:** 75, 1952.

5. Wybar, K. C.: Ocular Manifestations of Disseminated Sclerosis, Proc. Roy. Soc. Med. **45:**315, 1952.

The optic nerve in every eye I examined histologically showed some abnormality. In all but one case the nerve showed some degree of atrophy, and in that case it showed a marked increase of glial cells. The atrophic areas usually included a considerable portion of the papillomacular bundle but were never confined to it, and usually extended to nearby fibers and often to the peripheral fibers. None of the nerves showed total atrophy, but the rule was an irregular atrophy with predominance of the defect on the temporal side.

In all cases the optic nerve showed a considerable increase in the number of cells, especially the glial cells, with some fibroblasts and lymphocytes. These were

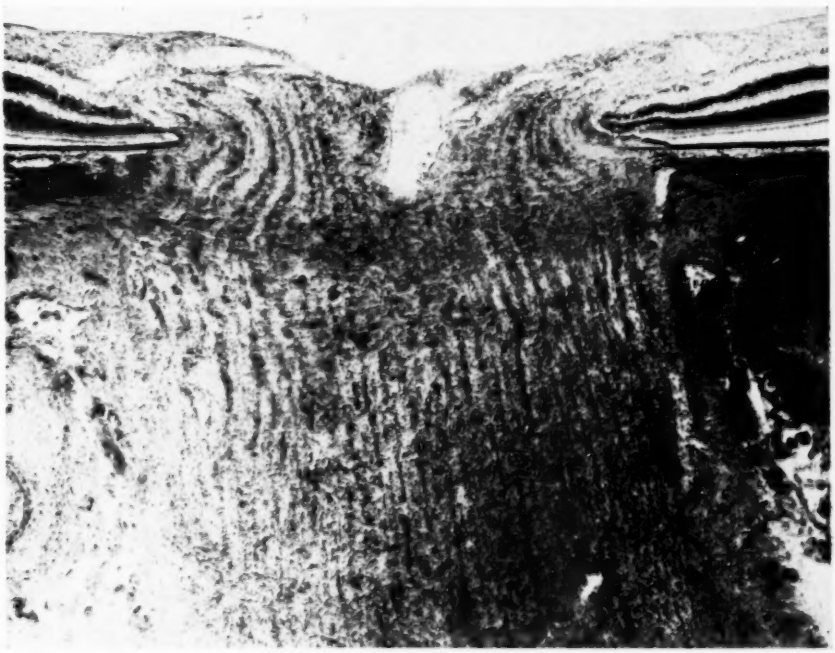


Fig. 1 (L. F.; P. M. 6124).—Multiple sclerosis.

The optic nerve on the temporal side is atrophic. The rest of the nerve is extensively infiltrated, mainly with glial cells.

irregularly distributed, with an occasional cluster of the cells and rarely a perivascular distribution.

The region of the disk was of considerable interest, as most of the eyes showed the changes that correspond to the clinical diagnosis of secondary optic atrophy. The surface of the disk and the area adjacent to it had undergone extensive gliosis. Newly formed connective tissue had developed, especially about the central retinal vessels and at the level of the lamina cribrosa. In one case a dense scar had formed at the level of the lamina cribrosa. The newly formed tissues had contracted and pulled the retinal elements inward.

Patients have been seen during the acute attack of papillitis with edema of the disk which pushed the retina aside and increased the size of the blind spot in a manner similar to the mechanism commonly noted in papilledema. In the stage of secondary optic atrophy seen in this autopsy group, the retinal elements were pulled centrally by the contracted scar on the optic disk.

The blood vessels on and near the disk had thickened, sclerosed walls in several cases. This is the pathological counterpart of the so-called "perivasculitis," a poor term, as this condition is not an inflammatory reaction. The thickened walls were seen as white stripes on each side of the blood column.

The retinal changes are interesting as they usually cannot be fully appreciated in the clinical examination. The atrophy of the fibers in the optic nerve extends to the nerve fibers in the retina. This involvement is not readily seen as one looks at the retina through the ordinary ophthalmoscope. However, an unusual demonstration was afforded us in a patient observed at Montefiore Hospital. She had medullated nerve fibers adjacent to the disk. An attack of acute optic neuritis developed. When the attack subsided, there were visual impairment and loss of the medullary sheaths of the nerve fibers in the retina, as shown in the fundus photograph taken a year later.[6] Loss of medullated nerve fibers with optic atrophy from other causes has been noted by Bachmann [7] and Fuchs.[8]

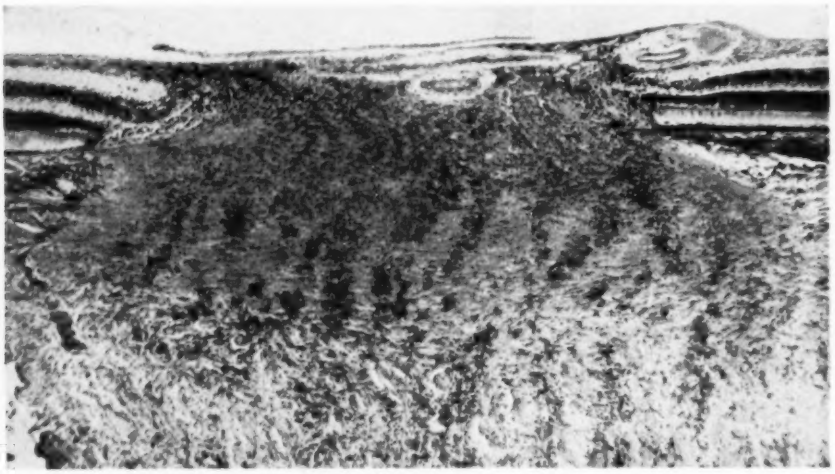


Fig. 2 (L. G.; P. M. 10842).—Multiple sclerosis.

The optic disk shows changes of secondary optic atrophy. New-formed glia and connective tissue have contracted and pulled retinal elements inward. There is marked sclerosis of the blood vessels on the disk.

As a natural aftermath of atrophy of the nerve fibers in the nerve and retina, the ganglion cell bodies atrophy. This is best seen at the macula, for a number of

6. Dr. Max Chamlin furnished these interesting illustrations.

7. Bachmann, R.: Schwund markhaltiger Nervenfasern in der Netzhaut nach Embolie der Art. centralis retinae, von Graefes Arch. Ophth. **17**:10, 1921.

8. Fuchs, A.: Die Erkrankungen des Augenhintergrundes, Vienna, Franz Deuticke, 1943, p. 27.

reasons. Normally, there is the greatest concentration of ganglion cells in this location, and they are arranged in a regular manner, so that changes are readily detected. In addition, in multiple sclerosis, most of the important damage strikes the papillomacular bundle and later causes atrophy of the ganglion cells at the macula. Changes in the ganglion cells in the peripheral retina are more irregular and are not as readily noted unless very marked and extensive.

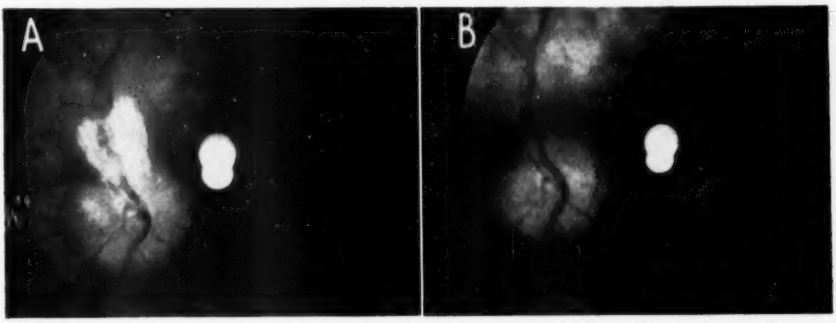


Fig. 3 (A. M.).—Optic neuritis.

(*A*) The fundus during an attack of acute optic neuritis demonstrates medullated nerve fibers above the disk. (*B*) One year later, the medullated nerve fibers have disappeared. The disk is atrophic, and some of the blood vessels show perivascular striping.

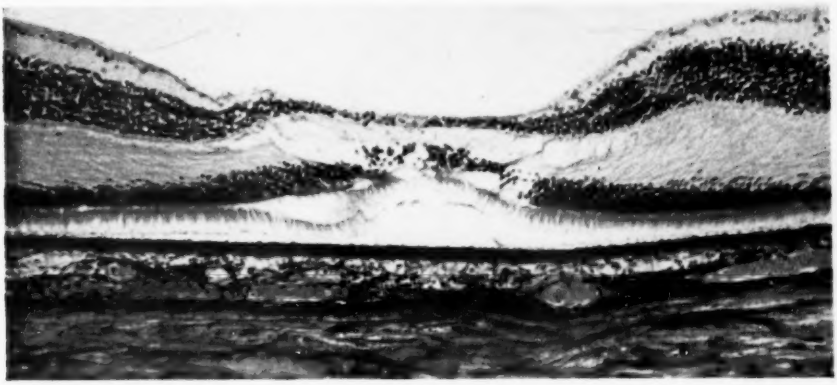


Fig. 4 (L. G.; P. M. 10842).—Multiple sclerosis.

The macula has a marked reduction in the numbers of ganglion cells. The defects in the other layers are apparently artifacts in the preparation of the slide.

A number of eyes showed these late changes in the macula. There was marked reduction in the number of ganglion cells, from the normal five or seven layers to one or three layers. The remaining cells in many cases were irregular and shrunken. This development is the macular atrophy of multiple sclerosis. The other layers of the retina were normal in most cases, except that a few showed a small loss of cells in the inner nuclear layer.

The loss of ganglion cells varied in pattern. In most cases there was a similar defect on both sides of the macula. In two there was a more marked loss on the nasal side, while in one the greater loss was on the temporal side.

ENCEPHALOMENINGOMYELITIS

Encephalomeningomyelitis is a term applied to a group of diseases of the central nervous system which many think is of viral origin and which may cause the clinical picture of optic neuritis. The ocular complications of encephalitis have recently been the subject of a review by Wagener.[9] An example is the case of M. G., a

Fig. 5 (M. G.; P. M. 11907).—Meningoencephalomyelitis. The chiasm has extensive areas of demyelination.

woman aged 37. Three months before her death she had an attack of acute optic neuritis in the left eye, and a few weeks later an attack in the right eye. Central vision was lost during the acute attack. Autopsy revealed extensive involvement of the central nervous system with a cellular reaction typical of this entity.

The general contour of the retina in this case was preserved, with a marked diminution of the ganglion cells at the macular zone, where they were reduced to an irregular layer one to two cells in thickness in the right eye and to about twice

9. Wagener, H. P.: Edema of the Optic Disks in Cases of Encephalitis, Am. J. M. Sc. **223**:205, 1952.

that number in the left eye. This atrophy apparently developed within the three months between the attack of optic neuritis and her death.

The optic chiasm showed extensive demyelination. In the optic nerves there was an extensive loss of nerve fibers in numerous patches. There was a marked increase in the cellular content of the nerve, mainly of glial cells, with some fibroblasts and lymphocytes. The disks were not elevated, but the increased glial and connective tissue elements extended over the margin of the disk into the nerve fiber layer. There was an increased number of small blood vessels, around some of which was perivascular infiltration with small round cells. The effects on the eyes and optic nerves in this case of encephalomeningomyelitis have many similarities to those in cases of multiple sclerosis. The mechanisms are probably very different and will be discussed later.

Fig. 6 (M. G.; P. M. 11907).—Meningoencephalomyelitis. The macula shows marked atrophy of the ganglion cell layer.

OTHER TYPES OF OPTIC NEURITIS

The commonest type of optic neuritis is secondary to chorioretinopathy from any cause. The optic neuritis varies with the severity of the attack and is more striking when the acute patch is near the disk. It can be seen ophthalmoscopically only when the media are sufficiently clear. Papillitis develops, owing to the extension of toxins or infections along the retinal veins or by transmission through the vitreous. The laboratory at Montefiore Hospital, as well as other eye laboratories, have large numbers of specimens with optic neuritis associated with endophthalmitis and sympathetic ophthalmia. Optic neuritis with papillitis was reported in cases of subacute bacterial endocarditis by Dienst and Gartner.[10]

The involvement of the optic nerve in the cases secondary to chorioretinopathy is somewhat irregular and is most prominent when the lesion is near the disk. The papillomacular bundle shows no special susceptibility.

10. Dienst, E. C., and Gartner, S.: Pathologic Changes in the Eye Associated with Subacute Bacterial Endocarditis: Report of 5 Cases with Autopsy, Arch. Ophth. **31**:198 1944.

This type of optic neuritis is obviously infectious in many cases, and the terminology is proper. Whether the changes in the optic nerve in cases of multiple sclerosis and the other demyelinating diseases should be called optic neuritis is questionable.

COMMENT

Multiple sclerosis frequently involves the optic nerve. The essential feature in this disease is the recurrence of attacks of degeneration of the myelin sheaths of the nerve fiber bundles in the white matter of the central nervous system. It is generally accepted that this is a degenerative, and not an inflammatory, condition. The old idea of a viral origin has been discarded by almost all modern workers. The term optic neuritis in this disease is therefore improper. It could be called the optic neuropathy of multiple sclerosis. Another term might be degenerative amblyopia, which would serve to differentiate this group from the toxic amblyopias.

A clinical differentiation has been made between optic neuritis which is accompanied by papillitis, and retrobulbar neuritis, which signifies the same disease without papillitis. This is a very questionable difference. A proper terminology would be optic neuropathy of multiple sclerosis with or without papillitis.

The optic nerve is not a nerve in the ordinary sense of the word. It is functionally and actually a tract in the central nervous system and is involved in multiple sclerosis along with other parts of the white matter of the central nervous system.

The typical plaques of multiple sclerosis have been well described by Zimmerman and Netsky.[11] They are comparable in different parts of the nervous system. The clinical symptoms, however, vary with the location of the plaque. Clinical recovery from any one attack is common. This recovery, however, is only partial, as can be determined by careful functional testing and pathologic studies.

The plaque in the optic nerve may attack any bundle of nerve fibers. Involvement of the papillomacular bundle causes a dramatic loss of vision and draws the patient's attention to the condition, so that a diagnosis is made in many cases. While the papillomacular bundle is frequently involved, the disease is by no means confined to it in the cases I studied. In addition, there is usually degeneration of nearby, as well as peripheral, fibers. In one case a large bundle of nerve fibers on the nasal side was atrophied.

In clinical series reported by many men they state that retrobulbar neuritis is far more frequent than optic neuritis. A plaque in the posterior part of the optic nerve would be expected to cause a primary type of optic atrophy, that is, a pale gray disk with a clear outline, with little or no vascular change.

Optic neuritis with papillitis has frequently been found to cause a secondary optic atrophy. This consists of a dirty gray, irregular disk with thickened vessels and perivascular striping.

Most of the eyes I examined histologically showed the changes of secondary optic atrophy. In a clinical study Schlossman and Phillips[12] report that a large percentage of their patients had the secondary type of optic atrophy.

---

11. Zimmerman, H. M., and Netsky, M.: Pathology of Multiple Sclerosis, A. Res. Nerv. & Ment. Dis., Proc. (1948) **28**:271, 1950.

12. Schlossman, A., and Phillips, C. C.: Optic Neuritis in Relation to Demyelinating Diseases, Am. J. Ophth., to be published.

It is very likely that in many cases the attacks affect the anterior portion of the nerve but do not cause edema of the disk and have been improperly called retrobulbar neuritis. In the plaques of multiple sclerosis, edema is not a prominent or an essential finding. The absence of edema of the nerve head does not prove the lesion is actually far behind the globe. Recurrent attacks which involve the anterior part of the optic nerve may be missed, especially in the presence of previous visual loss and partial optic atrophy. It is very difficult to decide the exact location of the plaque in the living patient.

The attack of optic neuropathy in multiple sclerosis is usually sudden in onset, and is followed by gradual recovery over a period of weeks or months. Nerve fibers not too badly damaged may recover function. However, careful functional testing usually brings out residual defects. As a late change, some degree of optic atrophy becomes apparent clinically. This will vary from pallor of the temporal portion of the nerve head to a marked secondary atrophy of the nerve.

An interesting feature in this study is that I found some degree of involvement in every case of multiple sclerosis in which the eyes and optic nerves were examined histologically. The clinical literature indicates a far lower incidence. Lisch,[13] in 1933, reported a histological study of the optic nerves and chiasms in 12 cases of multiple sclerosis. In every case there was some involvement, though in only six was the visual defect diagnosed in life. It appears that in multiple sclerosis the percentage of cases with involvement of the eyes is very high and that if the patients live long enough, almost all of them are likely to show ocular involvement. In multiple sclerosis, complete recovery from an attack of optic neuropathy is apparently not the rule, but residual damage is left in all cases.

Many of the optic nerves showed very extensive damage, so that it was questionable whether it all occurred in one attack. The clinical descriptions of multiple sclerosis often point out that one attack of optic neuritis is the rule and recurrences are exceptional. The pathological evidence makes this questionable. Elsewhere in the central nervous system large numbers of plaques of different ages is a common finding, and there is no reason that the optic nerve should be an exception. The extensive atrophy of the optic nerve suggests repeated attacks in many cases. After the initial attack has left much damage in its wake, recurrences are likely to be unnoticed.

It was pointed out above that an acute attack of optic neuropathy was diagnosed in life in only 2 of the 10 cases, though in all some involvement was apparent on histological study. Atrophy of portions of the optic nerve was evident in almost all cases. It is most likely that this atrophy was preceded by one or more plaques of the typical demyelination. However, the attacks were not diagnosed in most cases. A number of reasons are suggested for this. While the attack that causes a sudden loss of central vision is commanding in its attention, those that cause defects only in the paracentral fields, and even more particularly in the peripheral fields, may be unnoticed. This would be rather likely to occur in an autopsy group such as this. By the time these patients were admitted to the hospital, they were in an advanced state of deterioration, with many serious disabilities. Five of the 10 patients had nystagmus, and 6 had impairment of the extraocular muscles which

13. Lisch, K.: Die Veränderungen der peripheren Sehbahn bei multipler Sklerose, Arch. Augenh. **107**:380, 1933.

at times caused diplopia. These could be so disturbing that the patients would be less likely to notice the added visual disturbances of any subsequent attack of optic neuropathy.

Encephalitis apparently can produce the clinical picture of optic neuropathy with papillitis that resembles that seen in some cases of multiple sclerosis. However, the mechanisms are very different. In encephalitis the ganglion cells of the retina may be attacked first, as they are in other viral diseases, and the papillitis and optic atrophy are secondary. In multiple sclerosis the attack starts in the myelin sheaths of the nerve fibers, and atrophy of the ganglion cell bodies is secondary.

In encephalitis, the attack is properly called optic neuritis, as there is good evidence of its infectious nature.

SUMMARY

This report is based on the histological examination of the eyes and optic nerves of patients that had suffered from so-called optic neuritis. In multiple sclerosis a better term would be optic neuropathy with or without papillitis.

Fourteen eyes from 10 patients with multiple sclerosis for whom the diagnosis was verified at autopsy were examined. Every one of them showed some changes in the eyes and optic nerves, though the attack of optic neuropathy was diagnosed in only two of them during life. It is apparently missed in many cases.

The important findings are partial optic nerve atrophy with extension of this to the nerve fiber layer and the ganglion cells, being especially noted at the macula.

The eyes from one patient with encephalomyelitis were examined. This patient had bilateral optic neuritis three months before her death. The eye findings had some similarities to those found in multiple sclerosis, but the mechanisms are very different.

Optic neuritis is a common sequel to chorioretinopathy from any cause.

521 Park Ave.

Miss Hilda Bergen prepared the slides, and Mr. T. Herskovitz did the photography.

EFFECTS OF BETA IRRADIATION ON THE RABBIT LENS

LUDWIG VON SALLMANN, M.D.
CARMEN M. MUNOZ, A.B.
AND
ANNE DRUNGIS, A.B.
NEW YORK

KNOWLEDGE of early radiation-induced changes in the lens epithelium and of their significance for the development of cataractous lesions has advanced greatly in recent years. The high radiosensitivity of the germinative zone of the lens epithelium, particularly of the cell nuclei in this area, has been demonstrated in x-ray studies [1]; in other experimental series the slow progression of damage wrought by various forms of ionizing radiation has been followed, from the microscopically visible changes in the chromatin material of the nuclei to the ophthalmoscopically distinguishable opacities in the lens. On the basis of this enriched understanding of the pathogenesis of radiation cataract, the present study of the effects of beta particles on the lens was undertaken.

Although ophthalmologists who have used and recommended beta-ray therapy for various diseases of the eye [2] have been aware of the danger to the lens when the doses of radiation have had to be stepped up, to the best of our knowledge no systematic experimental work on this subject has been reported. The long latent period between the irradiation and the development of the cataractous changes has made clinical investigation clearly impractical, and the difficulty of making accurate cytological determinations on the mammalian lens has no doubt further impeded the accumulation of pertinent experimental data. Radiation cataract as a compli-

This study is based on work performed under Contract #AT-30-1-Gen.70 of the Atomic Energy Commission and was also supported by the Knapp Memorial Foundation.

From the Department of Ophthalmology and the Radiological Research Laboratory, Columbia University College of Physicians and Surgeons, and the Institute of Ophthalmology, Presbyterian Hospital.

1. von Sallmann, L.: Experimental Studies on Early Lens Changes After Roentgen Irradiation: III. Effect of X-Radiation on Mitotic Activity and Nuclear Fragmentation of Lens Epithelium in Normal and Cysteine-Treated Rabbits, A. M. A. Arch. Ophth. **47**:305, 1952.

2(*a*) Woods, A. C.: Treatment of Tuberculosis of the Anterior Portion of the Eye with Beta Rays of Radium, Arch. Ophth. **22**:735, 1939. (*b*) Iliff, C. E.: Beta Irradiation in Ophthalmology, ibid. **38**:415, 1947. (*c*) Ruedemann, A. D.: Beta Radium in Treatment of Corneal Lesions, ibid. **38**:556, 1947; Beta Radiation Therapy, ibid. **41**:1, 1949. (*d*) Hughes, W. F. Jr., and Iliff, C. E.: Effects of Beta Irradiation of the Rabbit Eye, Am. J. Roentgenol. **56**:502, 1946. (*e*) Friedell, H. L.; Thomas, C. I., and Krohmer, J. S.: Description of a Sr^{90} Beta-Ray Applicator and Its Use on the Eye, ibid. **65**:232, 1951. (*f*) Wilson, F. M., and Wilson, J. W.: Radioactive Strontium Therapy of the Eye, Corneal Biostandardization and Evaluation of an Applicator for Use in Ophthalmology, A. M. A. Arch. Ophth. **48**:686, 1952. (*g*) Hughes, W. F., Jr.: Beta Irradiation Therapy in Ophthalmology, Tr. Am. Ophth. Soc. **50**:469, 1952.

cation of beta-ray treatment of the human eye has already been described several times as a relatively early radiation effect, however, and its incidence will in all likelihood be considerably higher in the future. For this reason, an investigation of the relationship between the dose of beta radiation and its injurious effect on the lens epithelium seemed timely, especially in view of the growing popularity of this type of radiotherapy and the success claimed for it in the treatment of vascularization of the cornea.

MATERIALS AND METHODS

The Sr^{90} applicator manufactured by United States Radium Corporation, similar to the type (RA-1) made by Tracerlab, Inc., was used in this study. Since Wilson and Wilson [2f] have given a detailed description of this form of applicator, only the results of recalibrating the radiation source employed in the present study will be mentioned here. The measurements were made in the Radiological Research Laboratory, Columbia University College of Physicians and Surgeons.[3]

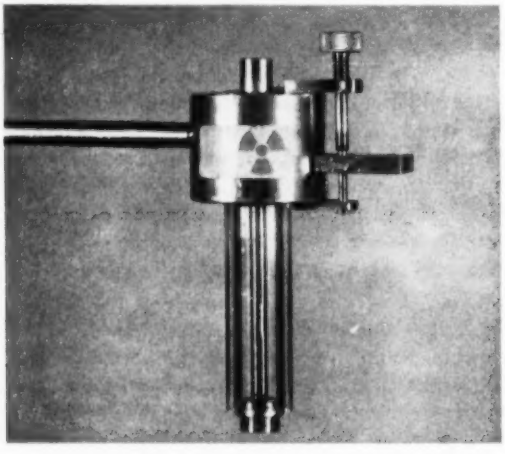


Fig. 1.—Sr^{90} applicator of the United States Radium Corporation.

To facilitate the handling, the commercially available applicator was modified by the removal of the plastic disc and the replacement of the Lucite casing with a hollow aluminum cylinder of the same dimensions. By means of a sliding arret in the aluminum absorber, the head of the applicator could be safeguarded within the shield or allowed to protrude to a degree desirable for irradiation. A Lucite cylinder could be screwed in the aluminum container to protect the investigator during irradiation (Fig. 1). These changes in the applicator unit were designed by Dr. Harald Rossi, of the Radiological Research Laboratory.

Experiments were performed on mature chinchilla rabbits, of an average weight of 2.5 kg. The right eyes were irradiated; the left were reserved as controls. After the introduction of light general anesthesia with pentobarbital sodium, small amounts of a 0.1% solution of dibucaine (Nupercaine) hydrochloride were injected subconjunctivally at the insertion of the superior rectus muscle and subcutaneously near the margin of the upper lid, for the placement of traction sutures at these points. By means of these sutures the limbus was sufficiently exposed in the upper half to bring the active area (7.8 mm. in diameter) of the applicator face in direct contact

3. Baily, N. A.; Gross, W., and Failla, G.: Isotopes and Beta Rays. C-5 Determination of Surface and Depth Doses for Beta Ray Eye Applicators, Annual Report on Research Project, U. S. Atomic Energy Commission NYO-4008, 1952, P. 57.

with the globe. The midline of the applicator face was aligned with the limbus and the axis of the applicator head set perpendicularly to the tangential plane of this area. The applicator head was held in place by means of clamps fixed to a stand. Surface doses of 2,000, 5,000, 10,000 and 20,000 rep were applied. All dosage values given in this paper refer to surface doses unless otherwise indicated.

Both eyes of a total of 53 rabbits were removed 1, 4, 7, 14, and 28 days after irradiation, and whole mounts of the lens epithelium were prepared for the cytological study of early changes. In addition, two rabbits for each dose level were kept for prolonged observation. As in previous studies, the mounts were prepared according to Howard's method,[4] i.e., fixed in Carnoy's solution, dehydrated, and stained by the Feulgen method; ephithelium and capsule were spread in the usual manner. For proper topographical orientation of the mounts, the pigment of the ciliary epithelium, which adheres to the anterior surface of the lens capsule, was carefully removed in the vertical meridian before the lens was completely dislodged. When the lens had been freed from the zonule fibers, the pigment was taken off with moist filter paper except for a narrow band in the temporal half of the horizontal meridian. This band served as a reference for identification of the sector of the lens which had been closest to the radiation source during the exposure.

In order that the early radiobiological effects on the lens produced by beta rays might be compared with those produced by x-rays, the right eyes in three groups of rabbits were exposed to the x-ray beam. Doses of 100, 500, and 1,500 r were used on a total of 60 rabbits. The technique of irradiation, the radiation factors, and the histological procedures used for the treated and the control eyes were the same as those described in reports of previous work.[5]

Several frozen eyes of mature rabbits and two human globes were bisected in the vertical meridial plane and measured for the purpose of establishing the critical distance of the limbal surface from the equatorial area of the lens.[6]

RESULTS

Cytological and Anatomical Examinations.—The tissue-depth doses of the Sr^{90} applicator used in the present study were reduced to 15.5% at a depth of 3 mm. and to 8.3% at 4 mm. (Fig. 2). With greater distances the decrease ceased to be linear on a semilog plot. In a Lucite phantom, Krohmer[7] measured the dose of another Sr^{90} applicator at the distance of 3 mm. as 9% of the surface dose. The sectors of the equatorial zone closest to the applicator were exposed then to approximately 300, 750, 1,500 and 3,000 rep, respectively, on the basis of the assumption that the surface dose was reduced to about 15% at the level of the lens equator.

The preparations of lens epithelium were examined, first, for effects of the radiation on cell division, and, second, for signs of cell damage, characterized by the extrusion of chromatin material from the nucleus. The number of dividing cells in the lens epithelium of the irradiated eye of each animal was compared with the number of dividing cells in the control eye. Since the mitotic index varies considerably, even among rabbits of the same breed, but does not differ more than 10% between the right and the left eye of a single animal, the counts of the treated eyes were expressed in percentages of the counts of the untreated

4. Howard, A.: Whole Mounts of Rabbit Lens Epithelium for Cytological Study, Stain Tech. **27**:313, 1952.

5. von Sallmann, L.: Experimental Studies on Early Lens Changes After Roentgen Irradiation : I. Morphological and Cytochemical Changes, Arch. Ophth. **45**:149, 1951.

6. Dr. H. M. Katzin, Director of the Eye-Bank for Sight Restoration, Inc., 210 E. 64th St., cooperated in supplying us with the human material.

7. Krohmer, J. S.: Physical Measurements on Various Beta-Ray Applicators, Am. J. Roentgenol. **66**:791, 1951.

CALIBRATED DEPTH DOSES FOR USED SR 90 APPLICATOR

THICKNESS mm H_2O	DOSE RATE rep/sec
0	16.42
0.5	12.04
1.0	8.82
1.5	6.47
2.0	4.75
2.5	3.48
3.0	2.55
4.0	1.37

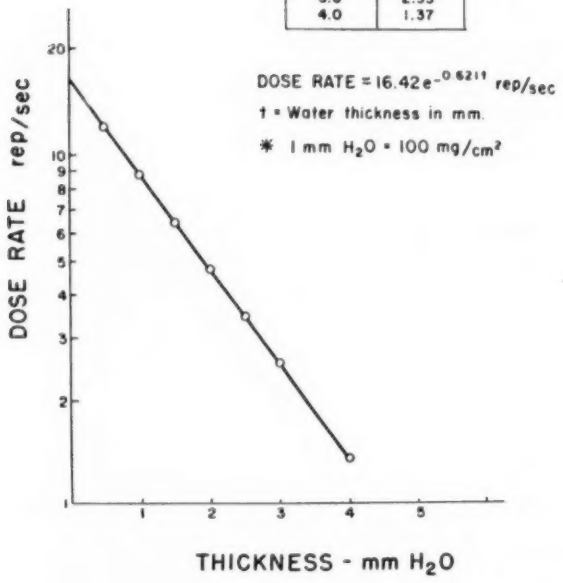


Figure 2

DISTRIBUTION OF DIVIDING CELLS AND DAMAGED NUCLEI IN FLAT PREPARATION OF LENS EPITHELIUM 7 DAYS AFTER IRRADIATION OF LIMBUS WITH 5000 rep BETA PARTICLES
(750 rep at lens equator)

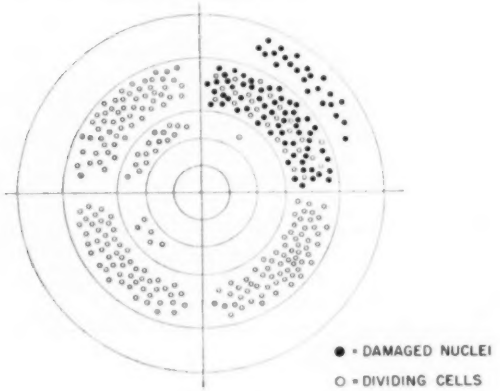


Figure 3

eyes. Extrusion of Feulgen-positive material from the nuclei occurs rarely in normal eyes. Thus, the absolute number of cells or residua of cells showing this change indicates the extent of the radiation damage and can be used for tabulation. In all instances the counts were obtained by examination of the entire lens epithelium. In most preparations radiation effects were seen solely or preponderantly in the sectors of the lens adjacent to the irradiated part of the limbus. An average record of the distribution of cells in mitosis and of cells with extruded chromatin globules is illustrated in Figure 3. It represents the results of the irradiation of an eye with 5,000 rep seven days prior to its removal. The evaluation of depression, recovery, and overcompensating increase of mitosis in a single preparation was difficult, since the dose of the absorbed radiation in the tissue decreases characteristically with distance; mitosis might still be depressed in one

TABLE 1.—*Effect of Beta Irradiation on Cell Division and Extrusion of Chromatin Material from Cell Nuclei of Rabbit Lens Epithelium**
(2,000 rep at limbus)

Rabbit No.	Time After Irradiation, Days	No. of Mitoses		Percentage Difference (Mitoses)	No. of Damaged Nuclei	
		O. D.	O. S.		O. D.	O. S.
696	1	155	226	−45.7	2	0
695	1	106	144	−26.0	4	0
711	4	167	Lost	....	11	..
716	4	178	167	+ 6.6	2	0
745	7	163	159	+ 2.5	0	0
717	7	108	Lost	....	0	..
631	7	157	155	+ 2.1	0	0
694	7	155	151	+ 2.5	1	0
628	14	126	104	+28.1	14	0
627	14	163	141	+15.6	34	0
760	14	85	80	+ 6.2	22	0
629	28	53	79	−33.1	5	0
630	28	160	149	+ 7.4	9	0

* It should be stressed that data on the effect on mitosis given in Tables 1 to 4 cannot be validly compared with data of studies in which the entire lens was exposed to a homogeneous x-ray beam. In the experiments with the beta applicator only a sector of the lens received a damaging dose of ionizing radiation, and this dose varied with the distance from the limbus.

zone but have entered the phase of overcompensating increase in the neighboring area which had received a slightly smaller amount of ionizing radiation.

Table 1 lists the two radiobiological effects on rabbits whose right eyes were exposed to 2,000 rep. Mitosis was partially inhibited on the first day, reached the normal level by the fourth day, and was very moderately augmented in the following weeks, with a 28% increase as the highest value. Unexpectedly, several damaged cell nuclei were noticed in the preparations of eyes examined one day and four days after irradiation; their number was slightly greater in the preparations examined two and four weeks after treatment, although none at all were found at the one-week interval.

In the experiments with 5,000 rep, the partial depression of mitosis lasted for one week after treatment, and the overshooting phenomenon was clearly developed in two weeks, with increases up to 60% (Table 2). At the four-week interval this effect had tapered off. The extrusion of nuclear material apparently did not take place in the first postirradiation week but was noted in the following week, with high readings in three experiments.

In the series in which 10,000 rep was applied the number of dividing cells was, with two exceptions, lower in the irradiated eyes than in the control eyes for the first week and rose consistently in the subsequent three weeks (Table 3). This phenomenon was accompanied by the appearance of damaged cells, the number of

TABLE 2.—*Effect of Beta Irradiation on Cell Division and Extrusion of Chromatin Material from Cell Nuclei of Rabbit Lens Epithelium*
(5,000 rep at limbus)

Rabbit No.	Time After Irradiation, Days	No. of Mitoses		Percentage Difference (Mitoses)	No. of Damaged Nuclei	
		O. D.	O. S.		O. D.	O. S.
742	1	26	59	−56.0	0	0
732	1	69	76	− 9.2	0	0
697	1	91	Lost	....	0	..
698	1	29	149	−81.0	0	0
713	4	42	54	−24.4	1	0
714	4	209	275	−31.6	0	0
589	7	96	179	−46.5	18	0
590	7	222	217	+ 2.2	83	0
761	7	49	Lost	....	1	..
47	14	173	108	+60.0	83	0
606	14	105	81	+29.9	18	1
607	14	153	113	+35.4	18	0
605	28	40	38	+ 5.3	2	0
602	28	120	104	+15.3	42	0

TABLE 3.—*Effect of Beta Irradiation on Cell Division and Extrusion of Chromatin Material from Cell Nuclei of Rabbit Lens Epithelium*
(10,000 rep at limbus)

Rabbit No.	Time After Irradiation, Days	No. of Mitoses		Percentage Difference (Mitoses)	No. of Damaged Nuclei	
		O. D.	O. S.		O. D.	O. S.
699	1	89	180	−50.5	0	0
700	1	124	159	−22.0	0	0
704	4	146	170	−14.1	1	0
705	4	221	202	+ 9.3	16	2
744	4	114	268	−57.5	0	0
735	4	138	151	− 7.9	9	0
747	7	158	132	+14.9	33	0
746	7	180	116	+55.3	30	0
748	7	116	107	+ 8.9	28	0
689	14	159	129	+23.2	22	0
688	14	178	108	+67.8	97	0
739	14	304	125	+152.0	25	0
681	28	224	127	+76.1	20	0
683	28	146	101	+44.5	46	0

which in one instance reached a high of 97. A comparison of Tables 2 and 3 shows that there was no marked difference in the results of the experiments with doses of 5,000 and 10,000 rep.

In the group of animals in which 20,000 rep was employed the inhibitory effect on cell division also persisted for one week and percentually exceeded the depression observed in the previous series (Table 4). Signs of damage to the nuclei in the germinative zone were seen at all time intervals, but in the second week were at their maximum (296 injured cell nuclei) in one preparation.

In the x-ray experiments the entire lens was subjected to the irradiation. Changes in the mitotic rate could be well evaluated and shown graphically (Fig. 4). For reasons given above, the radiobiological effect on cell division induced by contact treatment with beta rays cannot be used to show the degree of radiation damage. Emphasis was placed, therefore, on the occurrence of the second early sign of radiation damage. The incidence of injury to the cell nuclei determined for various dosage levels of beta radiations and of x-rays were averaged and illustrated in Figure 5. In view of the fact that in the case of beta irradiation only a sector of the lens equator was exposed to a relatively high dose, the extent of microscopically visible early cell damage can be considered similar for the two types of weakly ionizing radiations.

In the majority of experiments the characteristic effects on cell division and the cytological signs of radiation injury gradually progressed as the dose was

TABLE 4.—*Effect of Beta Irradiation on Cell Division and Extrusion of Chromatin Material from Cell Nuclei of Rabbit Lens Epithelium*
(20,000 rep at limbus)

Rabbit No.	Time After Irradiation, Days	No. of Mitoses		Percentage Difference (Mitoses)	No. of Damaged Nuclei	
		O. D.	O. S.		O. D.	O. S.
701	1	74	234	−68.2	0	0
702	1	65	165	−61.0	4	0
710	4	39	229	−83.0	0	0
715	4	72	171	−58.0	4	0
718	4	150	237	−36.7	17	1
741	7	108	132	−18.2	13	0
50	7	149	65	+129.0	163	0
759	7	61	107	−45.0	12	0
719	14	112	80	+40.0	78	0
720	14	186	123	+51.1	47	0
752	14	183	183	0	296	0
753	14	266	143	+72.5	99	0

increased, but the extrusion of chromatin from the nuclei occurred less frequently in some animals than in others of the same group. In the beta radiation series differences in the amount of nuclear damage among animals of the same group could have been caused by slight displacement of the active area of the applicator face in relation to the landmark of the limbus; however, a similar phenomenon was observed in animals treated with identical doses of x-rays. Since the technique could be standardized satisfactorily in this case, the diversity of the cell counts might best be explained by a difference in radiosensitivity of the lens epithelium from animal to animal.

In reports in which the conditions indispensable to avoidance of radiation damage to the lens have been discussed, the distance between the limbus and the lens equator has usually been assumed to be 4 mm. The measurements carried out in this study indicate that this figure should be corrected both for the rabbit and for the human eye. The linear distance between these landmarks measured 3 mm. in the eyes of mature rabbits and varied from 2.5 to 3.3 mm. in the human eye. Since a decrease of the distance between the radiosensitive tissue and the beta-ray source of from 4 to 3 mm. increased the depth dose from 9 to 15% of the surface dose, calculation for safer radiation technique should be based on these new values.

EFFECT OF 1 DOSE OF 100 r, 500 r AND 2000 r OF X-RAYS ON THE MITOTIC ACTIVITY OF THE RABBITS' LENS EPITHELIUM

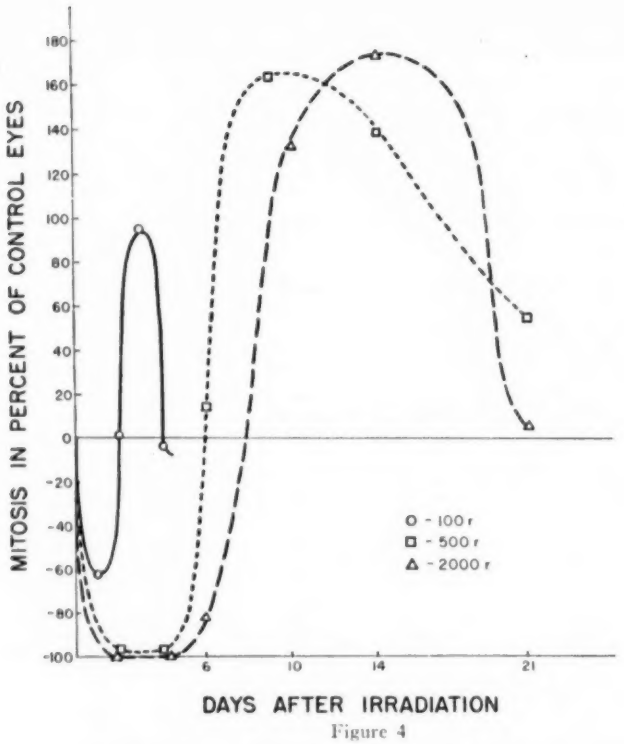


Figure 4

COMPARATIVE INCIDENCE OF NUCLEAR DAMAGE IN RABBIT'S LENS EPITHELIUM BETWEEN EYES IRRADIATED WITH BETA RAYS AND X-RAYS

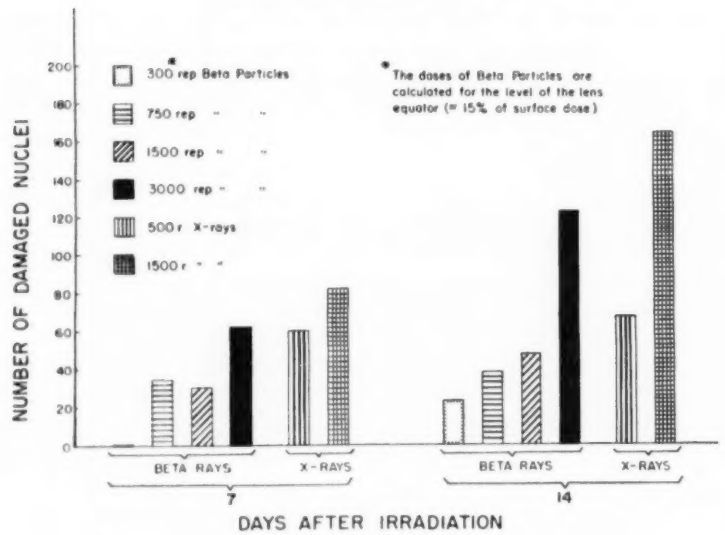


Figure 5

Examinations with Ophthalmoscope and Biomicroscope (Preliminary Results).—During an observation period of three months, cataractous changes developed in five of six eyes that had been treated with 5,000, 10,000, or 20,000 rep. These changes consisted of opacities in the sector of the lens closest to the active face of the applicator and involved the equatorial zone, as well as the area around the posterior suture. They either appeared in the form of bands or nets or were diffuse in character; not only were they located subcapsularly, but they encroached also upon the middle layers of the anterior and posterior cortex. In four instances these changes became visible one and a half months after irradiation; in one experiment the time interval was two and one-half months. Within the limits of the observation period in this small series, the opacity did not extend to other sectors but showed slow progression in the area around the posterior pole of the lens. The appearance of these partial cataracts was regarded as proof of the prognostic significance of the described early signs of radiation injury to the cell nuclei.

None of the rabbits irradiated with doses of 2,000 to 20,000 r showed corneal lesions except for one rabbit, in which irradiation with 20,000 r produced a transient opacity in the treated area. Obviously, then, injury to the lens can be produced by beta radiation at the limbus without biomicroscopically visible corneal damage. Wilson and Wilson [2f] determined the damaging dose for the cornea with 35,000 rep. Our results do not deviate from the observations of these authors.

COMMENT

Previous x-ray studies [1] conducted in this laboratory showed that at dosage levels of 500 r a considerable number of nuclei of the lens epithelium suffered early radiation damage and that mitosis was inhibited for four days. Cogan and Donaldson [8] observed circumscribed cataractous changes in mature rabbits from 100 to 150 days after the eye had been treated with 250 r of x-rays. Granular opacities were visible along the posterior suture and remained stationary for more than two years.[9] On the basis of available evidence, depression of cell division in the lens epithelium for four days or more and nuclear damage to an extent of about 50 injured nuclei per preparation suggest that a cataractogenic dose has been administered. In the present study, then, the question arose whether the conclusions derived from the experiment with exposure of the entire rabbit eye to the x-ray beam could be applied to contact beta irradiation, in which only one sector of the radiosensitive portion of the lens received a relatively high dose. The results of the reported series prove the validity of such a comparison. From the number of cells or cell residues with extrusion of chromatin globules, the development of a cataractous lesion could be predicted for the future. Five of six animals irradiated with doses of 5,000, 10,000, and 20,000 rep and observed for three months showed cortical opacities usually as early as six weeks after irradiation. In the rabbits exposed to 2,000 rep, on the other hand, no evidence of opacification appeared during this observation period.

At first glance, these observations seemed to be at variance with the results of recent studies of Wilson and Wilson [2f] and of Hughes.[2d, g] These investigators examined the damaging effects on the rabbit's cornea of beta irradiation with a

8. Cogan, D. G., and Donaldson, D. D.: Experimental Radiation Cataract: I. Cataracts in the Rabbit Following Single X-Ray Exposure, A. M. A. Arch. Ophth. **45**:508, 1951.

9. Cogan, D. G.: Personal communication to the authors.

Sr^{90} applicator and a radon applicator. No cataractous changes were observed in their series. The center of the cornea was selected for treatment, however; consequently, the distance between the active part of the applicator and the germinative zone of the lens epithelium was greater by several millimeters than the distance maintained with the technique employed in the present studies. The effective dose at the critical area of the lens was thus only a small fraction of the dose calculated for the irradiation of the limbus. Differences in the results could well be explained on this basis.

Since the cataractogenic dose for a single irradiation of the human eye is still a matter of conjecture, it is not possible to apply the results of observations on the rabbit eye directly to the human eye. On the assumption that the radiosensitivity of the rabbit lens epithelium may be as much as four times that of the human lens epithelium, the sensitive zone in the latter would be exposed to an unduly high, and probably cataractogenic, dose when 20,000 rep or more was applied at the limbus. The fact that the distance from the limbus to the lens equator in the human eye was found to be less than 3 mm. in two instances gives added emphasis to the risk involved in such treatment.

There is still great uncertainty as to the potentiality of the lens epithelium, and subsequently of the lens fibers, to recover from minimal radiation damage. Closely connected with this unsolved problem is that of the possibility of lens damage resulting from the additive effect of fractionated doses when the sum exceeds the cataractogenic level. From the results obtained on animals which were subjected to limbal irradiations with beta particles, and in view of the lack of sufficient information on recovery of the lens from radiation-induced microscopic lesions, it can be concluded that great caution should be exercised in the beta radiation treatment of marginal lesions of the cornea.

SUMMARY AND CONCLUSIONS

By means of a Sr^{90} applicator, the limbal areas of rabbits were irradiated with beta particles at dosage levels of 2,000, 5,000, 10,000, and 20,000 rep.

Cytological examination of the lens epithelium of 53 animals showed that radiation-induced damage to the nuclei of the germinative zone was limited to the sector closest to the irradiated part of the limbus. The extent of the cell injury depended on the dose. The observations of the present study confirm those of previous experimental series in which extensive early microscopic lesions in the lens epithelium were invariably followed by cataractous changes.

In five of six animals lens opacities developed within 10 weeks after irradiation with 5,000 rep or more. These opacities extended to and included the posterior pole of the lens. Despite the beta-radiation-induced damage to the lens, the area of the cornea which was in direct contact with the applicator was free of biomicroscopically visible lesions.

X-ray treatment of rabbit eyes in doses of 100, 500, and 1,500 r resulted in damage to the equatorial cells comparable to the changes induced by beta irradiation when the different conditions of the two experimental procedures were taken into consideration.

In view of the short distance of the limbus from the equator of the human lens, and the high radiosensitivity of the germinative epithelium of the lens, it is recommended that extreme caution be exercised when the limbal area of the cornea is to be subjected to beta irradiation in relatively high doses.

COMPARATIVE FEATURES OF PLASTIC AND/OR GLASS IN ARTIFICIAL-EYE CONSTRUCTION

STANLEY F. ERPF, D.D.S., M.S.
SAN FRANCISCO

SINCE the introduction of plastics into the field of surgical prosthesis, considerable interest has been manifested in the relative advantages of plastics as compared with other, more time-tested materials. This is true particularly in the realm of artificial-eye construction, where very little literature has been available on the nature of the various materials and techniques employed. Because of the lack of published information, the ophthalmologist is often at a disadvantage in advising the patient as to the type of eye prosthesis best suited to meet his individual requirements. The presentation of a standard of clear and comprehensive specifications is believed timely, therefore, in order to acquaint the ophthalmologist with the various types of artificial eyes available and to assist him in formulating his own standard of comparison as to their relative merits.

STANDARD OF COMPARISON AND REQUISITES

In order that a comprehensive comparison of the various features of artificial-eye restorations may be made, a standard of reference is needed. The following requisites are enumerated roughly according to importance: (1) tissue compatibility, (2) esthetic appearance, (3) durability of material, (4) color permanence, (5) adaptability of form, and (6) cost and availability.

1. *Tissue Compatibility.*—Tissue tolerance to artificial eyes is influenced by many factors. Age and environment of the patient, degree of recency and extent of surgical procedures, integrity of the lacrimal system, and soft-tissue tonus are but a few of the considerations which have a bearing on the success of a prosthesis from the standpoint of tissue compatibility.

The ideal material for an artificial eye must be nontoxic and sufficiently hard that it will assume and retain a high degree of luster when polished and subjected to use. The material employed should also be repellent to the formation of accretions precipitated from socket moisture. Special attachments sometimes incorporated into artificial eyes to afford increased motion under the control of ocular muscles must be of such a material and design as to produce no inflammatory reaction. Failure to observe the importance of each and all of these factors will cause the patient continuing discomfort and constant embarrassment because of tissue irritation and its associated excessive mucous secretions.

Coordinator of research and personnel training, Plastic Artificial Eye Program, United States Army, 1943-1946; Assistant Professor, University of California College of Dentistry.

The materials employed in artificial-eye construction fall into two categories: glass and plastics. The glass used is of two types, lead glass and soda glass. Lead glass, although much more durable than soda glass, has more or less fallen into disuse because of severe tissue reactions often caused by the lead content of the material. Soda glass, on the other hand, is much more compatible with the tissues but manifests to a much greater degree the disadvantage of solubility in lacrimal fluid. Over periods of from 18 to 24 months [1] sufficient erosion of the glass frequently will have taken place to render its surface rough and irritating to the patient. Increased mucous discharge results, causing a calculous accretion to precipitate on the glass, which still further aggravates the condition. Although these accretions can be removed by polishing, there is little that can be done to improve the underlying eroded surface. Erosion after use is especially evident if attempts have been made to change the original color of the restoration by additions of low-fusing glass to its surface. Low-fusing pigments containing a high percentage of soluble fluxes are often used to simulate vascular areas, with the result that erosion frequently occurs in the form of deep surface grooves coursing in a ramified pattern. Needless to say, such deterioration makes continued wearing of a glass restoration so affected extremely ill-advised.

The use of plastic as an artificial-eye material largely overcomes these disadvantages. Plastic does not erode in socket secretions and when highly polished actually repels the formation of accretions.[2] Constant slight friction of the eyelids and other structures over the surface of a plastic eye tends to maintain its original luster indefinitely. Unfortunately, plastic is only the equal of glass in scratch resistance when gritty foreign bodies find their way into the eye socket. Unlike glass, however, plastic can be re-buffed readily to restore its polish.

A definite advantage of plastic over glass for artificial eyes lies in its capacity to absorb moisture. Highly glazed glass is completely impervious to the retention of moisture within its substance. Lacrimal fluids wet only the surface of a glass restoration, and, as a consequence, this film is likely to evaporate rapidly under adverse circumstances, leaving the area exposed by the palpebral fissure dry, tacky, and very uncomfortable to lid movements. Artificial-eye wearers residing in hot, dry climates or in windy areas with low humidity are most definite in their objections to this undesirable feature of glass restorations. Plastic, as mentioned, is moisture-absorbent to the extent of about 2% in the case of methyl methacrylate, which is the material most widely used at the present time. This factor enables moisture of the lacrimal fluid not only to wet the surface of the restoration but to be contained actually within the plastic itself, acting as a tissue lubricant at such times as surface moisture may be temporarily deficient. For this reason, persons wearing artificial eyes employed in positions [3] where such evaporation is a hazard are most appreciative of the comfort afforded by plastic materials.

1. One isolated instance has come to my attention in which a glass eye was worn for eight years without ill effect.

2. Patients will frequently wear plastic restorations for several months at a time without removal for even so much as inspection or cleaning. Though this practice is not recommended, little harm results if normal secretions do not stagnate.

3. Among this group would be oven and furnace operators, engine mechanics, house painters, farmers, vehicle drivers, and so forth.

There is still another major advantage of plastic over glass as regards tissue compatibility, that of "thermocomfort." It is concerned with a temperature differential within various parts of the eye restoration. Most glass prostheses are thin-walled and hollow and enclose an air space at negative pressure which insulates the deeper surfaces of the restoration from those which are exposed by the palpebral fissure. This insulation of a thin-walled structure permits a sharp temperature delineation between those parts of the restoration which are in contact with tissue at body heat and the surface which is exposed most of the time to room temperature or the temperature of the immediate environment. Here, again, persons subjected to temperature extremes or to sudden changes in temperature find a glass prosthesis very uncomfortable.[4] Once more, plastic demonstrates its superiority over glass in overcoming the foregoing objection, since plastic restorations are usually solid throughout and enable temperature differentials to distribute themselves more uniformly, with only minimal delineation between the deeper and the more superficial portion of the prosthesis. Most artificial-eye wearers are quick to appreciate the advantages of plastic for this reason.

Occasionally even a highly polished and well-fitted plastic restoration may appear to be incompatible with soft tissues. Allergic reactions to plastic are often suspected, but oftenest it will be found that the plastic has been insufficiently processed in these instances. Factors of curing temperature, pressure, and processing time affect not only the hardness and density of plastic but the degree of its polymerization as well. Retention of only partially polymerized plastic in monomeric form always results in tissue reaction. Such restorations, if not porous, can often be rendered serviceable by further curing.

In summarizing factors of tissue compatibility, assuming that a given restoration has been well fitted, one may conclude that there is no substitute for a chemically inert, slightly moisture-absorbent, and microscopically smooth material, free of scratches, porosity, and other irregularities. Any compromise with perfection in this connection should condemn the prosthesis, *ipso facto*.

2. *Esthetic Features.*—Exclusive of the degree of artistry evident in various makes of artificial eyes, there are several structural differences between restorations made of glass and those made of plastic. Structural differences also exist among the various types of plastic eyes available. The criterion of esthetic perfection would seem to depend not only upon impeccable craftmanship but also upon whether the anatomical structures found in the natural eye are reproduced in the artificial eye with relative fidelity, on the one hand, or by means of an illusory effect, on the other. It is not within the intended scope of this paper to discuss the technical details employed in producing various esthetic effects; it is the apparent result of these technical procedures which is to be considered.

Granted the axiom that things equal to the same thing are equal to each other, it naturally follows that given reproductions of anything as constant in character as a human eye will, as a matter of course, resemble one another very closely. This is especially true if such reproductions are made with masterful fidelity. The *quod*

4. Patients will often complain of headache similar to that produced by having eaten a very cold substance too fast.

erat demonstrandum here is that esthetic differences between well-made artificial eyes of glass and of plastic are very slight indeed. Many will reproduce the general appearance of a natural eye so closely that their artificiality is virtually undetectable at any distance. Such perfection is not always observed, unfortunately; and, although the casual observer may not always detect which eye is artificial, he may suspect or be aware of the presence of an artifice in many instances.

Several important features must be considered in evaluating the esthetic differences among the various types and qualities of artificial eyes available.

(*a*) The corneoscleral junction must be diffused. In restorations of high quality this feature is reproduced by feathering the scleral material into nothingness onto the perimeter of the material representing the cornea. In poorly made restorations, or those of inferior design, the corneoscleral junction is abrupt, sharply circumscribed, and harsh in appearance.

(*b*) The pupil should be an aperture produced by actual perforation in the member representing the iris. The illusion of a pupillary aperture produced by covering the center of the iris member with a spot of black pigment invariably results in optical distortion of the pupil, especially when viewed obliquely or from the side. Glass restorations and many types of plastic restorations do not conform to optimum standards in this respect.

(*c*) The iris must possess a third-dimensional depth in order to appear lifelike at close ranges of observation. Most glass restorations possess this attribute, often more so than is considered desirable. In plastic eyes, sufficient iris depth is perceivable only in restorations of better quality. Single-plane iris reproductions produce a dull and lifeless appearance, especially when viewed at conversational or less than conversational distances. Considerable artistry is required to effect a natural third-dimensional depth in either glass or plastic materials.

(*d*) The vascularity overlying the sclera should be reproduced with materials which resemble blood vessels in appearance. For this purpose, in plastic eyes, red filaments of appropriate material are employed which afford a realistic simulation, especially with adroit application. A somewhat less natural effect is observed in some plastic restorations in which the simulation of vascularity has been obtained by linear scribing and staining with red dyes. In glass eyes the veining material is fused directly to the surface of the restoration, but in plastic the veining is usually subsurface, due to the overlay of clear plastic representing the conjunctiva. This, naturally, still further enhances the lifelike appearance, because of preservation of anatomical relationships.

(*e*) The surface pigmentation of the sclera in most instances should be confined to the normally visible areas of the sclera. This refinement depends, of course, upon the artistry of the eye maker. All too often little attempt is made to confine surface pigmentation to the area where it normally occurs. Instead, the entire anterior surface is uniformly pigmented, or, what is worse, an over-all scleral color is selected which most closely matches the localized pigmentation in the region of the palpebral fissure. Similarly, the yellowish adipose depositions found over the sclera medial to the iris are often not reproduced as an entity, but are allowed to influence the choice of sclera color as a whole.

Generally speaking, the more closely an eye restoration reproduces normal anatomical structures, the more satisfactory its esthetic appearance will be. Naturally, certain exceptions will exist, since it is frequently necessary to match various abnormalities in order to obtain an optimum over-all effect. In artificial-eye work, illusory effects produced by unperforated pupils, two-dimensional irises, harsh corneoscleral junctions, and inscribed vascularity are but poor and easily discernible substitutes for accurate anatomical reproduction of these all-important structures. *Ars est celare artem* is proverbial—truly, that art is the concealment of art is paramount in this field.

3. *Durability of Material.*—Perhaps the most striking difference between glass and plastic artificial eyes is in respect to their relative fragility. In glass, both the single-walled "shell" type and the double-walled "reform" type, are very susceptible to mishandling and shock. The hollow "reform" restoration is also subject to spontaneous breakage, or even explosion *in situ* (implosion). Causes of such breakage are several and include faulty tempering of the glass during fabrication, sudden changes in temperature [5] and weakened areas due to faulty construction or surface erosion. Considering that the wall thickness of the average glass restoration is less than that of a Christmas-tree light bulb, it is indeed amazing that the general period of its usability is as long as it is.

There is another type of artificial eye which, fortunately, is now becoming obsolete. It is a glass-plastic combination, in which the glass iris member is encased in a plastic portion representing the sclera. Its disadvantage lies in the dissimilar properties of the two composite materials. Unequal coefficient of expansion and other factors render it difficult to maintain a bond between glass and plastic. As a consequence, delamination often occurs between them. Delamination manifests itself as a mirror-like sheen or as a milky or cloudy area between the two materials employed. Such deterioration may begin as a result of dehydration of the plastic, overheating during polishing operations, sudden jar or shock, or for unexplained reasons during the process of normal wear.

Plastic artificial eyes, on the other hand, are practically indestructible under almost all conditions of use. They are exceptionally resistant to rough handling not only because of the inherent strength of the material but also because they are usually made solid throughout. The wearer of a plastic eye is relieved of the fear of breakage under any and all circumstances and is never burdened with the necessity for special precautions in inserting and removing the restoration, such as leaning over a towel or bedspread to cushion its accidental fall. Aside from the easily remedied possibility that its polish may be marred, the plastic artificial eye will withstand being dropped in the wash basin, bounced on the floor, or stepped upon, without untoward damage. Plastic artificial eyes are definitely the answer to the problem of durability.

4. *Color Permanence.*—Fading of color and other changes in over-all color occurring as a result of aging after fabrication of an artificial eye stem from two sources: first, oxidation and other chemical changes taking place in the pigments themselves, and, second, masking of colors by surface stains.

5. Such as cold drafts or hot blasts of air. The simple act of entering a warm room from a cold exterior or vice versa will frequently cause breakage.

Pigments in glass restorations are subjected to blowtorch temperatures during blowing and shaping. As would be imagined, all oxidation and color change that is to take place in the glass occurs during the heat in fabricating. No appreciable color deterioration appears in the color of a glass prosthesis as a result of aging or exposure to the ultraviolet component of natural light. Glass materials are definitely at a disadvantage, however, from a standpoint of superficial staining, which over a period of time tends to darken any areas where the pores of the glass have been exposed by erosion or etching. Indeed, even etching alone, without staining, can produce a chalky haze over the surface of the iris area sufficient to obscure both its design and its color.

With regard to plastic artificial eyes, early, and even many present, designs show signs of color fading to a distressing degree. Inexperienced fabricators often use certain pigments with no consideration of their fugitive properties. As a consequence, fading can be demonstrated in a poor restoration often within a matter of a few hours' exposure to direct sunlight.[6] Only light-fast metallic oxides and earthy pigments are used in well-made plastic artificial eyes. These are carefully selected and blended to prevent any combination which might be detrimentally affected by either processing temperatures or conditions of use. No appreciable color change takes place in plastic artificial eyes of better quality, even after repeated relining, modification, and reprocessing.

5. *Adaptability of Form.*—Artificial eyes frequently require delicate adjustments in form for the purpose of establishing and maintaining proper visual alignment. It is often desirable to change the size of a restoration after its fabrication in order to effect the correct width and length of the palpebral fissure. The corneal curvature must be identical with that of the natural eye which it is intended to match, since the size, shape, and disposition of the all-important corneal highlights are influenced thereby. These factors, namely, accuracy in establishing visual alignment, fissure dimensions, and corneal curvature, are absolutely essential in producing a beautifully matched artificial eye which will challenge detection. In my opinion, minute attention to these requisites is even more important than exact coloring.

In the case of the glass restoration, little can be done to change its size or shape after blowing is completed. Its form remains as unalterable as a light bulb.[7] In this connection, plastic has a distinct advantage over glass. With plastic materials, the necessary refinements can readily be made by grinding and repolishing if decrease in size or contour is desired. If increase is indicated, additions can be made and the restoration reprocessed. In fact, the number of additions that can be made is almost unlimited, since very little deterioration occurs in the curing process. The plastic prosthesis may even be altered in form by heating and warping by pressure if desired.

6. Some early types of restorations contained irises made by means of colored photographic prints and film. These faded readily because of the light-fugitive dyestuffs employed.

7. Since no individualizing alterations are possible after completion of glass restorations, a sizable assortment is necessary from which to choose. For this reason, glass-artificial-eye depots are not considered adequately stocked unless upward of 100,000 restorations are on hand. The mathematically progressive aspects of supplying an artificial eye to satisfy any possible combination of size, color, shape, curvature, etc., can be readily appreciated in this connection.

Recently, much attention has been directed to special implant devices. Such implants utilize a more harnessed action of the ocular muscles than is possible with the conventional Snellen form. The use of these devices requires a special surgical procedure following enucleation of the eye. Some modification of the prosthesis is also necessary in the way of incorporating studs, inserts, rings, clips, mesh screens, magnets, or the like. Glass does not lend itself to this type of treatment, but plastic readily accommodates such innovations.

Considerable caution must be exercised in preparing the anenophthalmic socket for the reception of implants. The implant is not always tolerated, and extrusion or expulsion of the device is frequently observed. In carefully selected instances, however, it is possible to utilize implants which can impart an almost normal range of movement to an appropriately made plastic artificial eye.

6. *Cost and Availability.*—A distressing unavailability of artificial eyes occurred during and immediately after World War II, but the supply for the most part is now equal to the demand.[8]

Table of Comparison

	Glass	Glass-Plastic	Plastic
Tissue compatibility	G	G	E
Cosmetic appearance	G	F	E
Durability	F	F	E
Color permanence	E	P	E
Adaptability of form	P	G	E
Cost and availability	E	F	G

Generally speaking, glass eyes remain the least expensive so far as initial cost is concerned. One must consider replacement expenses in any long-range appraisal, however. As has been stated, the average life-in-use of a glass eye is only 18 to 24 months. By comparison, plastic artificial eyes will last much longer. Since their first use in quantity by the military forces during World War II, many have been in use for several years or more without deterioration. Although the initial cost of a plastic artificial eye is still somewhat greater than one made of glass, the over-all expense to the patient when amortized over a long period of years is much less. This is especially true in a patient in whom tissue changes require frequent modification.

SUMMARY AND CONCLUSION

The present popularity of plastic restorations has minimized the factor of competition in the field of plastic-artificial-eye manufacture. For this reason, there are many inexperienced and unqualified technicians in the field. Frequently, the results obtained by these operators leave much to be desired. The ophthalmologist should not be hasty in condemning plastic as an appropriate material because of isolated instances in which questionable results were observed. Plastic artificial eyes of good quality have proved themselves superior to glass eyes in almost all respects. It is possible to place well-made plastic prosthesis in properly prepared orbits which will challenge detection at virtually any distance.

450 Sutter St.

8. Cessation of German imports was responsible. The monopolistic cartel in control of glass-artificial-eye manufacture was broken by the wartime development of a superior plastic substitute.

BIBLIOGRAPHY

Explosion of Artificial Eyes, Queries and Minor Notes, J. A. M. A. **110**:307 (Jan. 22) 1938.

Hayes, W. M.: Collapse of Glass Eyes in the Orbit, Am. J. Surg. **67**:510 (March) 1945.

Urbanek, J.: Explosionartig geplatzter Prothese in der Orbit., Ztschr. Augenh. **53**:270, 1924.

Erpf, S. F.; Wirtz, M. S., and Dietz, V. H.: Plastic-Artificial-Eye Program, U. S. Army, Am. J. Ophth. **29**:984 (Aug.) 1946.

Murphy, P. I., and Schlossberg, L.: Eye Replacement by Acrylic Maxillo-Facial Prosthesis, Naval M. Bull. **43**:1085 (Dec.) 1944.

Bethke, E. G.: Criteria and Guide for Evaluation of Ocular Prostheses, Am. J. Ophth. **35**:527 (April) 1952.

Clinical Notes, New Instruments and Techniques

TRANSPORTATION OF NORMAL HUMAN EYES

JAMES G. FOWLER, M.D.
BUFFALO

IN THE PAST four years, the scientific business concerned with the transportation of normal human eyes has taught us the observation of several precautions:

1. The eye should be partly suspended in cold, sterile physiological solution in a moist chamber. The moist chamber together with normal movements of the fluid in the half-filled container will prevent drying of the corneal epithelium.

2. The cornea should not be constantly immersed in the solution. This precaution minimizes any possible osmotic effect between the solution and the corneal epithelium.

3. The eye should be fixed in a constant position without external pressure, thus avoiding any injury to the corneal epithelium or stroma.

4. The sterile bottle which contains the eye should not be subjected to injury by immersion in unsterile melting ice.

5. The eye should be refrigerated at as low a temperature as can readily be produced by melting ice, and the low temperature maintained for 24 hours or longer.

6. The outside of the entire container should bear identification of its contents and instructions for rapid and proper handling by air express.

Figure 1 illustrates the whole assembly. The insulated jug has an opening at the top and bottom. This allows the inner metal container and its contents to be put firmly in place while the jug is empty. Then the jug is upended and filled with ice cubes through the bottom. A broad metal band built onto the entire jug shields this lower opening. Our observations show that this assembly will maintain a temperature of +3 C. for 36 hours.

The inner metal container is made of strong, rustless steel. It is large enough to hold two bottles, each containing one eye. The metal half-tube grasps the bottles firmly and protrudes above them ½ in. (1.3 cm.), thus enabling one to grasp the protruding metal and insert or withdraw both bottles easily without fear of breakage. The metal rack (Fig. 2) which supports the eye is made of one piece of thin, rustless steel, which can be bent easily to fit the eye. It and the bottle are easily sterilized. The upper metal loop and the leg below fit the bottle exactly and hold the eye in the center of the bottle. The metal platform on which the eye rests has a hole to admit the optic nerve. An ordinary pin thrust through the protruding nerve will hold the cornea upright and prevent the eye from rolling around. The side-supports

From the Eye-Bank and Research Laboratory, University of Buffalo School of Medicine.

Fig. 1.—The insulated jug (*b*) has an opening on the top (*c*) and another one on the bottom, which is shielded by a broad metal band (*d*). The inner metal container (*a*) is placed into the upper opening (*c*). The metal half-tube (*f*) grasps two bottles (*e*) and is placed into the inner metal container. The cover (*g*) closes firmly the upper opening of the jug and fastens the inner metal container and the half-tube, with the bottles.

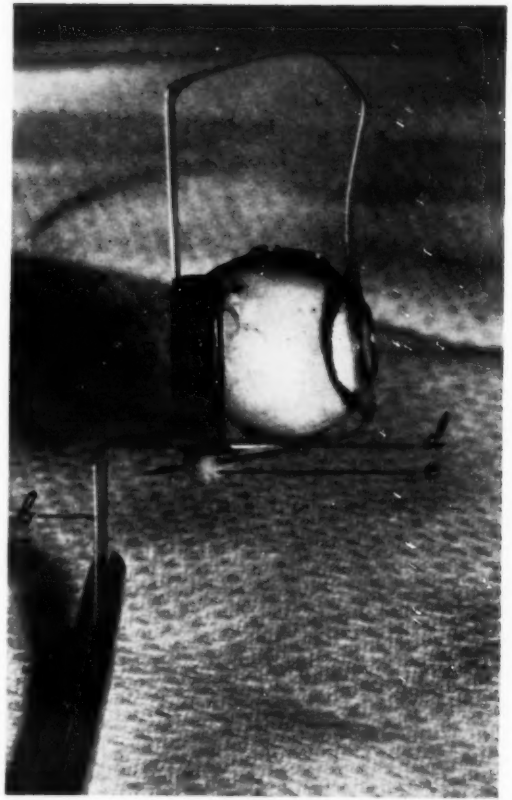


Fig. 2.—The metal rack holding the eye. The upper metal loop (*c*) and the leg below (*b*) fit the bottle exactly. The metal piatform (*a*) has a hole through which the optic nerve (*e*) is passed. An ordinary pin (*d*) thrust through the optic nerve holds the eye in the right position.

can be bent to touch the eye and aid in its free suspension and support. If there is no stump of nerve, episcleral black sutures can be used to fasten the eye to the metal platform.

We believe this container meets most requirements for transporting and preserving normal human eyes for a period of 36 hours. We have used the container to transport eyes to many eye surgeons within distances of 150 to 650 miles of Buffalo. All have reported the eyes to have been received in good condition.

The manufacture of this entire apparatus is the result of cooperative efforts of business concerns whose officers are either members or friends of Lions clubs. Poloron Products, Inc., New Rochelle, N. Y., made the double-ended jug; Hasenstab Brothers, Buffalo, made the inner metal container and the metal half-tube; Kenmore Precision Corporation, Kenmore, N. Y., made the metal eye rack. Joseph A. Albrecht spent many hours designing parts to meet our professional approval and enlisting manufacturer's aid, most of which was donated.

Ophthalmological Reviews

ULTRAVIOLET RADIATION AND VISION

JOHN C. OGILVIE, B.Sc. M.A.
TORONTO, CANADA

IN THIS review, ultraviolet radiation refers to the spectral region from approximately 300 to 400 mμ; in other words, the near ultraviolet rays. In many textbooks the visible spectrum is said to end at 400 mμ, and the ICI (International Commission on Illumination) luminosity curve does not extend beyond 380mμ, but shorter wave lengths than this have been reported to be visible on several occasions. The biological effects of the wave lengths of about 300 mμ are well known; they produce erythema and, in the eye, photophthalmia. Although it is generally recognized that the shorter wave lengths cannot penetrate to the retina, it is suggested that those between 300 and 400 mμ can have a harmful effect on vision. It is the purpose of this review to discuss the visibility of this band of the spectrum and its possible effects upon visual function. The reader should look elsewhere [1] for general information on the physical properties of ultraviolet radiation, and its chemical and physiological effects.

HARMFUL EFFECTS OF ULTRAVIOLET RADIATION

With the introduction of the arc lamp about 1880 and its increasing use in industry, cases of photophthalmia became not uncommon. This syndrome, due to the overexposure of the eyes to ultraviolet rays, had already been described by Charcot in 1875, and its more frequent occurrence stimulated research in the field. The literature on the effects of ultraviolet radiation on the eye was reviewed by Walker,[2] Duke-Elder,[3] Sheard,[4] and, most recently, Cogan.[5]

Many exaggerated claims were made by the earlier workers; ultraviolet radiation was said to be the cause of cataract, senile macular degeneration, erythropia,

This is Human Resources Report No. 51, Project No. D77-94-20-17) of the Defence Research Medical Laboratories.

1. (*a*) Blum, H. F.: Physiologic Effects of Sunlight on Man, Physiol. Rev. **25**:483-530, 1945. (*b*) Ellis, C., and Wells, A. S.: The Chemical Action of Ultraviolet Rays, revised and enlarged edition by F. F. Heyroth, New York, Reinhold Publishing Corporation, 1941. (*c*) Judd, D. B.: Basic Correlates of the Visual Stimulus, in Handbook of Experimental Psychology, edited by S. S. Stevens, New York, John Wiley & Sons, Inc., 1951, pp. 811-867. (*d*) Koller, L. R.: Ultraviolet Radiation, New York, John Wiley & Sons, Inc., 1952. (*e*) Laurens, H.: The Physiological Effects of Radiant Energy, American Chemical Society Monograph Series, New York, Chemical Catalog Company, Inc., 1933.

2. Walker, C. B.: Systematic Review of the Literature Relating to the Effects of Radiant Energy upon the Eye, Proc. Am. Acad. Arts & Sc. **51**:760-818, 1916.

3. Duke-Elder, W. S.: Text-Book of Ophthalmology: Vol. 1: The Development, Form and Function of the Visual Apparatus, London, Henry Kimpton, 1932.

4. Sheard, C.: The Physiological Effects of Radiant Energy, Especially upon the Human Eye, New York J. Med. **23**:292-300, 1923.

5. Cogan, D. G.: Lesions of the Eye from Radiant Energy, J. A. M. A. **142**:145-151, 1950.

and other diseases; but in 1916 most of these claims were proved false by an authoritative investigation by Verhoeff and Bell.[6] By an extensive series of experiments on rabbits, they showed that abiotic effects could be obtained only with wave lengths shorter than 305 mμ. The liminal exposure capable of producing corneal damage was estimated to be 2×10^6 erg-seconds/per square centimeter. Since the cornea and lens absorb these wave lengths very strongly, 19 times the minimal exposure needed for corneal damage was required to produce an effect on the lens, and even 150 times this amount affected the lens to a depth of only 20 μ. Verhoeff and Bell, therefore, concluded that the abiotic ultraviolet radiation from any artificial-light source in normal use was incapable of causing retinal damage.

There has been recent confirmation of Verhoeff and Bell's work, by Cogan and Kinsey.[7] In studying the action spectrum of keratitis of the rabbit cornea, they found the peak sensitivity of the cornea to be at 288 mμ, with the curve falling off to zero at 305 and 260 mμ. From this as a whole band, the liminal corneal-damage exposure was 2×10^6 ergs, but only 0.15×10^6 ergs was required from radiation at 288 mμ. Except in extreme concentrations, no abiotic effect was produced by wave lengths over 305 mμ.

In 1929 Duke-Elder and Duke-Elder [8] reported histological changes in the retina of a rabbit after exposure to ultraviolet rays. One early investigator, Birch-Hirschfeld [9] had reported similar findings; his experiments were repeated by Verhoeff and Bell, who categorically disagreed with them, finding no retinal changes whatsoever.

The Duke-Elders' findings are rather interesting. These investigators realized that their results could not be due to the abiotic wave lengths, and they concluded that what had occurred was "a pathological intensification of physiological processes of vision." [10] In support of this, they mentioned similar histological changes in the retina due to the action of light, found by other workers.[11] The Duke-Elders' hypothesis has not as yet been confirmed, but it is of interest in connection with the recent controversy over the effects of ultraviolet radiation on dark adaptation.

Morgan [12] has discussed possible causes for the many complaints that have been made against fluorescent lighting. The chief culprit was said to be glare, but the possibility of ultraviolet radiation effects was recognized, since from the fluorescent lights some ultraviolet rays are emitted, even down to 303 mμ. Morgan did not indicate that there is any action on the retina, but did suggest that "eyestrain" may arise because of a continual reflex attempt to accommodate, owing to the blurring of the retinal image from the fluorescence of the lens. Another suggested cause of

6. Verhoeff, F. H., and Bell, L.: The Pathological Effects of Radiant Energy on the Eye: An Experimental Investigation, Proc. Am. Acad. Arts & Sc. **51**:629-759, 1916.

7. Cogan, D. G., and Kinsey, V. E.: Action Spectrum of Keratitis Produced by Ultraviolet Radiation, Arch. Ophth. **35**:670-677, 1946.

8. Duke-Elder, W. S., and Duke-Elder, P. M.: A Histological Study on the Action of Short-Waved Light upon the Eye, with a Note on "Inclusion Bodies," Brit. J. Ophth. **13**:1-37, 1929.

9. Birch-Hirschfeld, A.: Die Wirkung der ultra-violetten Strahlen auf das Auge, von Graefes Arch. Ophth. **58**:469-562, 1904.

10. Duke-Elder and Duke-Elder,[8] p. 31.

11. Duke-Elder and Duke-Elder,[8] p. 27.

12. Morgan, L. D.: There Is Something Wrong with our Fluorescent Lighting Applications, Illum. Engin. **41**:275-285, 1945.

ocular complaints from fluorescent lighting was proposed by Harmon.[13] He based his theory upon a report by Ley [14] which stated that in a certain office lit by fluorescent lamps a large number of the employees had eye complaints, the symptoms in every case being similar to those of ocular ariboflavinosis. Harmon believed that the riboflavin in the cornea is destroyed by the ultraviolet rays from the fluorescent lamps and that the resulting deficiency may affect visual function.

ULTRAVIOLET RADIATION AND DARK ADAPTATION

That exposure to ultraviolet rays may impair dark adaptation is by no means a new suggestion. In 1926 Heine [15] reported a number of ophthalmological case histories, all of which included among their symptoms an impaired dark-adaptation threshold. By prescribing Euphos glass spectacles, which do not transmit radiation of wave lengths below 400 mμ, he was able to improve adaptation in every case, and he concluded that exposure to ultraviolet radiation was the cause of the impairment. Siegfried [16] tested this conclusion experimentally. His subjects were dark-adapted for one hour. Then, with the visual fields separated by means of a septum, the right eye was illuminated by an incandescent lamp, and the left was exposed to a mercury vapor lamp with the abiotic radiations filtered out. All wave lengths below 500 mμ from the incandescent lamps were cut out by oiled paper. Five-candle and 50-candle lamps were used. The adaptation curves were obtained with a Nagel adaptometer and compared. No consistent differences were found between the preadaptation effects of the two sources; in general, the 50-candle lamp interfered more with adaptation than the mercury vapor lamp. It should be pointed out that the mercury vapor lamp and the incandescent lamps had not been equated for brightness.

The controversy on dark adaptation has been reopened by Wolf, who, in a series of papers, has ascribed to ultraviolet radiation impairing effects upon vision. His first two papers [17] dealt with the effects of ultraviolet rays on chicks. He made use of the nystagmus response at the flicker threshold and found that after exposure to ultraviolet rays for one hour the light threshold for flicker, at the rate of 30 per second, was impaired about 20%. His ultraviolet-ray source was a bank of three 250-watt mercury vapor lamps. After the chicks had been kept in the dark for 40 to 50 minutes, the threshold had returned to normal. Wolf used a series of filters, each one transmitting radiation farther into the ultraviolet spectrum, and found there was a definite relation between the extent of the impairment and the range of wave lengths. Wave lengths above 365 mμ had no impairing effects. Wolf obtained similar results from the effects of ultraviolet rays upon dark adaptation in chicks. After exposure to ultraviolet rays, the chicks were placed in a cage with a cylindri-

13. Harmon, D. B.: Lighting and the Eye, Illum. Engin. **39**:481-500, 1944.

14. Ley, E. B.: Study of Illumination, Illum. Engin. **39**:500-505, 1944.

15. Heine, L.: Klinische Untersuchungen über die Wirkung gewisser Glassorten auf den menschlichen Lichtsinn und seine Störungen, Klin. Monatsbl. Augenh. **76**:37-45, 1926.

16. Siegfried, W.: Experimentelle Untersuchungen über den angeblich schädingenden Einfluss der ultravioletten Strahlen auf die Adaptation des Auges, von Graefes Arch. Ophth. **120**:526-539, 1928.

17. Wolf, E.: Effects of Exposure to Ultraviolet Light on Visual Thresholds, Proc. Nat. Acad. Sc. **31**:236-241, 1945; Effects of Exposure to Ultraviolet Light on Subsequent Dark Adaptation, Proc. Nat. Acad. Sc. **31**:349-355, 1945.

cal system of vertical bars revolving 1 to 1.5 times per second. The light intensity was increased, and the threshold was defined as the intensity at which the nystagmus response appeared. From these points an adaptation curve was plotted. Once again it was the wave lengths under 365 mμ which produced impairment, and the extent of impairment was related to the wave length. Wolf [18] then proceeded to demonstrate similar effects on the dark adaptation of the human eye. Using a visual discriminometer, he plotted curves for six normal subjects. They were preadapted for 10 minutes to the light from a 250-watt mercury vapor lamp diffused through a screen, giving a brightness of 6,250 mL. (millilamberts). By the interposition of filters, the cut-off point in the ultraviolet region was varied. The subsequent curves showed that after exposure to ultraviolet rays not only was the threshold of rod adaptation raised, but the onset of rod adaptation was delayed. For the six subjects the mean rise in threshold was 0.25 log unit. In addition, the curves for two aphakic subjects were presented, and these showed even greater impairment than did the curves for the normal subjects. Wolf suggested that the absence of any effect of ultraviolet radiation on the cones is due to the yellow macular pigment. He continued these researches in a further series of experiments,[19] using fluorescent lamps of various types as light sources. As before, the ultraviolet radiation present in these sources was found to impair dark adaptation to about the same extent. At the same time, Wolf cited supporting evidence concerning the effect of sunlight on night-vision thresholds. It had been found [20] that sunlight had a marked effect on these thresholds, an action which could be prevented by the use of sunglasses. Wolf mentioned that the glasses selected absorbed ultraviolet rays and pointed to this fact as confirmation of his results. However, Hecht and associates [20] thought that the ultraviolet component of sunlight contributed little to the reduction of the night-vision threshold. Peckham and Harley [21] demonstrated that the most important factor is total-light transmission of the sunglasses. One type, which transmitted ultraviolet rays but had a total transmission of only 10 to 12%, was much more effective in protecting scotopic sensitivity than the usual type of sunglasses, which had 35 to 50% transmission but did absorb ultraviolet rays.

Ludvigh and Kinsey,[22] who were critical of Wolf's results, tested for changes in critical fusion frequency and intensity discrimination on human eyes after exposure to ultraviolet rays. No differences were found. Wolf [23] pointed out that they were testing cone functions and that, as he had already noted that ultraviolet radiation affected only rods, no differences were to be expected.

18. Wolf, E.: Effects of Exposure to Ultraviolet Light on Human Dark Adaptation, Proc. Nat. Acad. Sc. **32**:219-226, 1946.

19. Wolf, E.: Effects on Visual Thresholds of Exposure to the Radiation Below 4000 Angstroms, Tr. Am. Acad. Ophth. **53**:400-413, 1949.

20. Hecht, S.; Hendley, C. D.; Ross, S., and Richmond, P.: The Influence of Exposure to Intense Sunlight on Subsequent Night Vision, Bureau Medical Research Project No. X-442 (Av-233-W), April 26, 1945.

21. Peckham, R. H., and Harley, R. D.: Reduction in Visual Acuity Due to Excessive Sunlight, Arch. Ophth. **44**:624-627, 1950.

22. Ludvigh, E., and Kinsey, V. E.: Effect of Long Ultraviolet Radiations on the Human Eye, Science **104**:246, 1946.

23. Wolf, E.: Effects of Ultraviolet Radiations on Visual Thresholds, Science **105**:366, 1947.

However, in a more recent paper, Zigler, Wolf, and King [24] found that ultraviolet radiation desensitizes both foveal and parafoveal cones, an effect which had not been observed before because of the speed of cone adaptation. The investigation concerned the effects of surround brightnesses, one of which was a slowing of the rate of cone adaptation when the surround is near the photopic threshold. Under these conditions impairment by ultraviolet radiation was demonstrated by raising of the final adaptation level and by a further slowing of the adaptation process not only in rods, as reported previously, but also in parafoveal cones.

The effects of ultraviolet radiation upon night vision are of considerable practical importance; for example, one method of aircraft cockpit illumination makes use of ultraviolet radiation with fluorescent paint on the dial markings. Keil [25] concluded that the exposure for five minutes to the direct rays of a standard ultraviolet-ray source used in United States Air Force aircraft raised the light threshold 0.4 log unit. There was complete recovery in less than 2.5 minutes. Luminous paint activated by the lamp produced no measurable effect, nor did the radiation reflected from the instrument panel. He considered that the decreased sensitivity of the eye was due primarily to the visible light from the lamp and the fluorescence of the lens, rather than to the ultraviolet rays. Lee [26] found that exposure to a landing signal officer's ultraviolet lamp for 15 and 60 seconds raised the adaptation threshold 0.1 and 0.32 log unit respectively; the effects disappeared within three minutes. Langstroth and associates [27] found that exposure to ultraviolet radiation had no effect on the rate of dark adaptation, but their experimental design is such that no definite conclusions can be drawn.[28]

Sexton, Malone, and Farnsworth [29] tested Wolf's findings on the effects of fluorescent lamps. They first confirmed that preexposure to ultraviolet rays from a mercury vapor lamp could raise the dark-adaptation threshold as much as 0.5 log unit. In each of two experiments, one subject was preadapted for 10 minutes to incandescent light at 165 foot-lamberts. In the second experiment he was exposed also to a small mercury vapor lamp for 10 minutes. The normal adaptation curve was obtained by averaging the results in five trials, but the curve after exposure to

24. Zigler, M. J.; Wolf, E., and King, E. S.: The Influence of Surround Brightness and Short Wave Components of Radiation on Dark Adaptation, J. Optic. Soc. America **41**:354-359, 1951.

25. Keil, F. C.: The Effect of Aircraft Cockpit Fluorescent Lighting on Visual Acuity and Dark Adaptation, U. S. Air Force School of Aviation Medicine, Project No. 64, Report No. 1, July 1, 1942.

26. Lee, R. H.: Effect of Short Exposures to Radiation from a Landing Signal Officer's Lamp on Dark Adaptation, Bibliography of Scientific and Industrial Reports Publication Board, No. 23041; abstracted, Psychol. Abstr. **20**:4515, 1946.

27. Langstroth, G. O.; Batho, H. F.; Wolfson, J. L.; Maclaren, E. H., and McLeod, M. J.: The Effect of Exposure to Ultraviolet and Infrared Radiation on the Rate of Darkness Adaptation, Department of National Defence of Canada, Directorate of Chemical Warfare and Smoke, Extra-Mural Research in Chemical Warfare and Smoke, Project No. C. E. 128, Jan. 11, 1944.

28. Preliminary work in this laboratory indicates that exposure to an ultraviolet cockpit lamp has no effect on the scotopic acuity threshold.

29. Sexton, M.; Malone, F., and Farnsworth, D.: The Effect of Ultraviolet Radiation from Fluorescent Lights on Dark Adaptation and Visual Acuity, Medical Research Laboratory Report No. 169 **9**:301-317, 1950.

the mercury vapor lamp was based on only one trial.[30] Having tested this part of Wolf's results, Sexton, Malone, and Farnsworth turned to the effects of fluorescent lamps. A 15-watt white fluorescent lamp was used in conjunction with a filter of Plexiglas, which absorbs most of the radiation below 400 mμ. A 100-watt incandescent lamp was also used in later experiments. The two observers were preadapted by reading for one hour under the appropiate illuminants and then adapted for a four-hour period. Dark-adaptation thresholds were measured every half-hour. No differences in the thresholds were found after preadaptation to the three illuminants—fluorescent light, ultraviolet-shielded flourescent light, and incandescent light. The same experimenters also tested for changes in visual acuity, but none were found.

Recently Hulburt[31] compared the effects of prestimulation by different colors on the time of dark adaptation. Eight monochromatic colors and the 365-mμ line from an 85-watt mercury vapor lamp were used. The colors, but not the ultraviolet radiation were equated for brightness. The general conclusion reached was that with shorter wave-length a longer time was needed for adaptation. However, the ultraviolet-ray source hardly interfered with adaptation at all, as it was regained completely after 5 to 10 seconds.

Peckham[32] attempted to reconcile Hulburt's results with those of Wolf. By using Hulburt's data, he computed the "light adaptation effectiveness" of the various wave lengths for the spectral output of a fluorescent lamp, and then for the same light as transmitted by one of Wolf's filters. The values derived show that the unfiltered light would have more effect on adaptation than would the filtered light. Thus, the effect of ultraviolet radiation, as reported by Wolf and others, may be explained by reference to brightness factors alone. It may be that this ingenious explanation gets at the nub of the difficulty in reconciling the studies on ultraviolet radiation and adaptation. In none of them were the unscreened and the screened (or filtered) sources equated for brightness. Possibly this inequality accounts for improved thresholds when filtered sources are used, since normally the brightness would be less.

The most recent report on adaptation and ultraviolet radiation was made by Wald.[33] Critical of Wolf's results, Wald repeated the former's experiments, using the same apparatus. The subjects were exposed to a screen illuminated with a 250-watt mercury vapor lamp with a brightness of about 15,000 mL. at the center. The procedure was to expose both eyes to this screen for 10 minutes with an ultraviolet-ray-absorbing filter interposed, plot the adaptation curve, then expose both eyes again, allowing the ultraviolet rays to irradiate them, and plot the second curve. Wald's own spectral adaptometer was used. With four curves from two subjects, neither rod nor cone differences were found between the two conditions. No differences were found when the two eyes were exposed simultaneously, one to ultra-

30. Farnsworth, in a recent personal communication, is rather dubious about these curves, as subsequent research, although tentative, reveals no effects.

31. Hulburt, E. O.: Time of Dark Adaptation After Stimulation by Various Brightnesses and Colors, J. Optic. Soc. America **41**:402-404, 1951.

32. Peckham, R. H.: A Proposed Method for Predicting Light Adaptation, J. Optic. Soc. America **42**:65, 1952.

33. Wald, G.: Alleged Effects of the Near Ultraviolet on Human Vision, J. Optic. Soc. America **42**:171-177, 1952.

violet and the other to nonultraviolet rays. However, with aphakic subjects there were disturbances at the first part of the curve, though the final threshold was the same. Wald explains this finding on the basis of the increased sensitivity of the aphakic eye to wave lengths below 400 mμ. Thus, there would be an even greater brightness difference between the filtered and the unfiltered light from the mercury vapor lamp. To test this hypothesis, he exposed the aphakic subject to ultraviolet rays of between 310 and 415 mμ and then to white light of high brightness. The thresholds were considerably lower for the ultraviolet radiation, and the subject stated that the ultraviolet rays alone had appeared dimmer than the white light. Wald also discussed the experiments of Wolf, Zigler, and associates, on the effects of the ultraviolet rays emitted by fluorescent lamps. To compare their ultraviolet-radiation output with that from the mercury vapor lamp, he used a photocell with a microammeter and a filter combination transmitting the 330- to 390-mμ band. The deflection produced by the mercury vapor lamp was 1.3 μam. at the distance of the eye from the screen, while at a shorter distance from a fluorescent lamp the deflection was only 0.4 μam. In view of this, he did not consider the latter of Wolf's experiments worth repeating.

Goodeve and co-workers,[34] when comparing the photosensitivity of visual purple with the scotopic sensitivity curve, gave the adaptation curves for wave lengths 546 and 365 mμ for both a normal and an aphakic subject. Threshold was reached at approximately the same time for the two subjects, and in the case of the aphakic subject the two thresholds were practically the same. Pinegin,[35] also, compared the relative adaptation curves for wave lengths down to 365 mμ. Like the results of Goodeve and colleagues, all Pinegin's curves are of a similar nature, the slopes being almost the same and threshold being achieved after the same length of time.

For evaluation of the results of the various researches noted above, it is necessary to arrive at some idea of how ultraviolet radiation may impair visual function, if indeed it does. The Duke-Elders' suggestion that since the abiotic wave lengths cannot penetrate to the retina their results must have been due to the band of 300 to 400 mμ has been mentioned. They pointed out the greater potency of these wave lengths in chemical reactions and suggested that the changes found were due to an overstimulation of the visual mechanism. Wolf has hypothesized that ultraviolet radiation may act directly upon the photosensitive pigments of the retina or else affect adaptation by the brightness of the fluorescence of the ocular media. Whichever it is, he noted that the physiological effect was large in comparison with the amount of radiation. On the other hand, Wald and Peckham considered that the change in threshold, when it occurs, may be due to the increased brightness of the unfiltered ultraviolet-ray source, and Wald found effects only on aphakic subjects.

Wolf's work has been criticized on the basis of the fact that no ultraviolet rays can reach the retina. There are few data on the transmission of the human eye for shorter wave lengths, although indirect evidence may be obtained from luminosity curves extending into the ultraviolet region.

34. Goodeve, C. F.; Lythgoe, R. J., and Schneider, E. E.: The Photosensitivity of Visual Purple Solutions and the Scotopic Sensitivity of the Eye in the Ultra-Violet, Proc. Roy. Soc., London, s.B. **130**:380-395, 1942.

35. Pinegin, N. I.: Absolute Photopic Sensitivity of the Eye in the Ultra-Violet and in the Visible Spectrum, Compt. rend. Acad. sc. URSS **43**:157-158, 1944.

ABSORPTION OF ULTRAVIOLET RAYS BY THE EYE

The fact that the limit of the visible spectrum at the violet end is set by transmission of the eye was first realized by Bruecke, as early as 1845. Since the limit of transmission provides an indirect estimate of the limit of vision, there are several determinations of this value. The most extensive reports are those by Shoji,[36] Hosoya,[37] Hoffmann,[38] Hallauer,[39] and Graham.[40] Reviews of the earlier work are given by the first three and also by Duke-Elder.[3] All except Hoffmann used a spectrographic method. The transmitted spectrum of the eye was photographed and the last appearing line noted. Hoffmann, instead, observed the fluorescence of the cornea and lens. He passed approximately monochromatic beams of light into the eye and noted when fluorescence first appeared, thus finding when the lens and cornea started to absorb. It should be noted that Hoffmann, by virtue of his technique, was able to use eyes in vivo, whereas all the others used morbid ones.

The results obtained by these investigators are in general agreement. The limit of transmission of the cornea and of both the aqueous and the vitreous humors is about 295 to 300 mμ. The lens is the most important absorbing medium; its absorption increases greatly with age, showing wide individual differences. Hoffmann found that fluorescence first appeared at about 390 to 400 mμ and inferred that absorption started there. In general, the limit of transmission is reported to be about 380 mμ at the age of 20. Hosoya, with a range of from 4 fetal months to 75 years, obtained values increasing with age from 310 to 404 mμ. In extreme old age even higher wave lengths may be absorbed. Hosoya also found a band of selective absorption in fetal lenses between 350 and 380 mμ.

These results are only qualitative, as they tell nothing of the amount of absorption at different wave lengths. Moreover, very few investigators have established absorption curves for the eye. The first was established by Roggenbau and Wetthauer,[41] whose primary interest was in the infrared region. Their curve for an ox eye extended across the visible spectrum, but no explanations or data were given. The only curve for the human eye is given by Ludvigh and McCarthy.[42] They used four eyes from elderly patients, and, since the absorption of the lens is much higher in old age, they based their computed figures on the absorption of lenses from a group with an average age of 21.5 years. It was noted that there was a wide variation in the absorption of the lenses of both groups, though less among the younger. The curve plotted from their data is shown in Figure 1. Only the

36. Shoji, Y.: Untersuchungen über die Absorption der ultravioletten Strahlen durch die Augenmedien, Mitt. med. Fak. Tokio **29**:61-129, 1922.

37. Hosoya, Y.: Über die Alterverschiedenheit der Ultraviolettabsorption der menschlichen Augenmedien, Tohoku J. Exper. Med. **13**:510-523, 1929.

38. Hoffmann, W.: Zur Messung der Ultraviolettabsorption von Hornhaut und Linse am lebenden Auge, Ztschr. Augenh. **63**:38-47, 1927.

39. Hallauer, O.: Über die Absorption von kurzwelligen Licht durch die menschliche Linse, Klin. Monatsbl. Augenh. **47**:721-730, 1909.

40. Graham, W. P.: The Absorption of the Eye for Ultraviolet, Am. J. Physiol. Optics **4**:151-160, 1923.

41. Roggenbau, C., and Wetthauer, A.: Über die Durchlässigkeit der brechenden Augenmedien für langwelliges Licht nach Untersuchungen am Rindesauge, Klin. Monatsbl. Augenh. **79**:456-464, 1927.

42. Ludvigh, E., and McCarthy, E. F.: Absorption of Visible Light by the Refractive Media of the Human Eye, Arch. Ophth. **20**:37-51, 1938.

final absorption coefficients for the whole eye are given; it is not possible to compare their figures for the separate parts of the eye.

Figure 1 also shows the curve obtained by Kinsey [43] for the rabbit eye. For comparison, the limits of transmission of the rabbit and the human eye, as given by Shoji, are included.

Goodeve and colleagues [34] and Wald [44] both give scotopic sensitivity curves for normal and for aphakic subjects. An approximate curve for the absorption of the lens can be obtained, but it should be noted that it is only an indirect estimate, the data being from different subjects. The logarithmic differences of the aphakic and the normal curves yield the optical density of the lens, from which the transmission

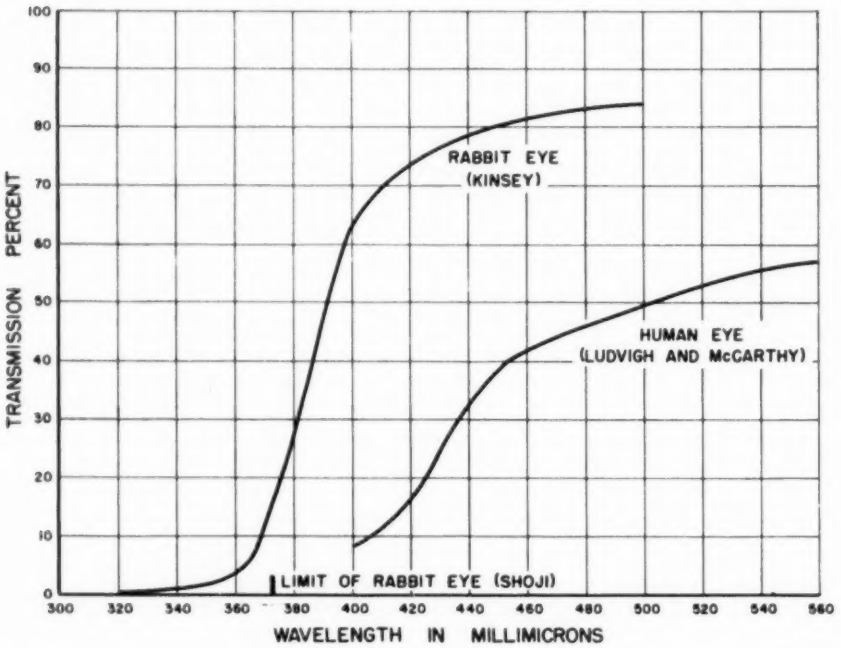


Chart 1.—Spectral transmission of the eye.

may be obtained, since optical density is equal to the log of the reciprocal of the transmission. Both these curves are shown in Figure 2, and they agree fairly well. Kinsey's curve for the rabbit lens is also given, as well as Hosoya's estimates for the limit of transmission of the human lens.

The only quantitative study in vivo of the absorption of the eye is that by Salomon.[45] She obtained curves showing the increase in the absorption coefficient

43. Kinsey, V. E.: Special Transmission of the Eye to Ultraviolet Radiation, Arch. Ophth. **39**:508-513, 1948.

44. Wald, G.: Human Vision and the Spectrum, Science **101**:653-658, 1945.

45. Salomon, F.: L'absorption sélective de la lumière par le cristallin, Rev. opt. (théor. instrumen). **29**:632-637, 1950.

for different wave lengths, including 365 mμ, relative to 546 mμ. Her method was ingenious and consisted of measuring the relative brightness of the light diffused by the lens at various wave lengths. She concluded that there is a marked increase in absorption below 404 mμ and that the absorption curves show wide individual differences.

There is an additional factor in the transmission of the eye, the macular pigment. Wald [44] gave a transmission curve obtained from an extract of macular

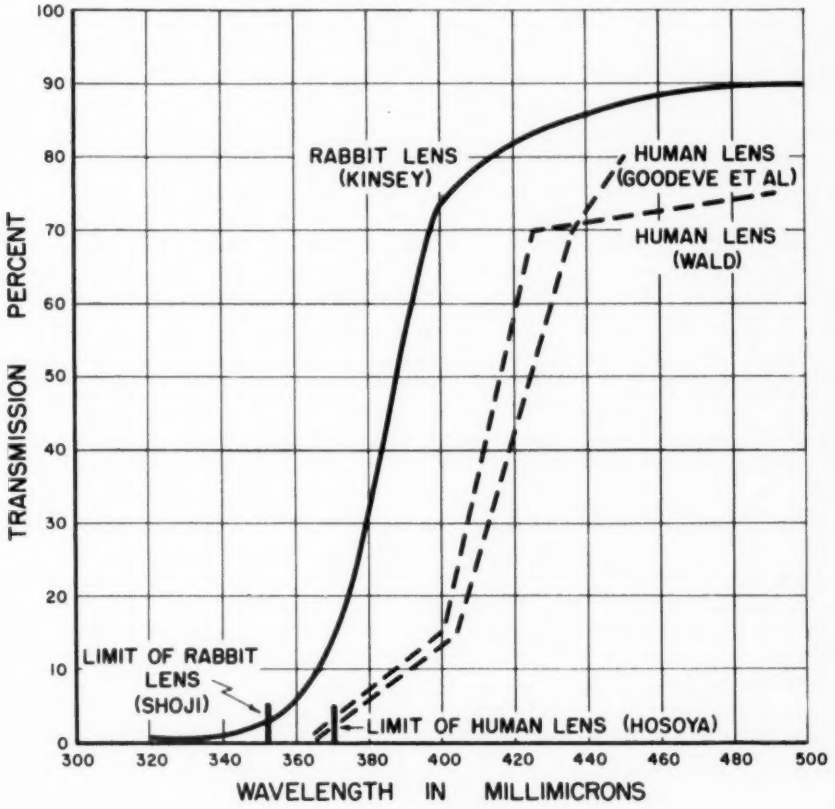


Chart 2.—Spectral transmission of the lens.

xanthophyll which agrees with sensitivity differences between foveal and peripheral cones. The pigment begins to absorb at a wave length below 550 mμ and reaches a maximum at 450 mμ.

FLUORESCENCE AND COLOR SENSATIONS

Work on the fluorescence of the ocular media up to 1948 has been reviewed by Klang [46] and is summarized briefly here. The lens and the cornea are the only parts

46. Klang, G.: Measurement and Studies of the Fluorescence of the Human Lens in Vivo, Acta ophth., Supp. 31, 1948.

of the eye which fluoresce to any great extent when exposed to ultraviolet rays, and of the two the fluorescence of the lens is far more intense. The color of the fluorescence of the cornea appears to be bluish-white. Its spectrum is roughly continuous and extends from 430 to 660 mμ. Its intensity increases slightly with age. This fluorescence is excited by wave lengths from 315 to 360 mμ.

Fluorescence of the lens is produced by wave lengths from 300 to 400 mμ, the most effective wave lengths being between 360 and 370 mμ. The fluorescent spectrum is continuous from 410 to 700 mμ. The fluorescent intensity of the lens, as of the cornea, increases with age, and the fluorescent spectrum changes. Klang had added considerably to our knowledge of the variables affecting fluorescence of the lens. He used an exciting wave length of 365 mμ and measured photometrically the fluorescence from human lenses in vivo. He confirmed the increase of fluorescence with age and found that there was a relative increase in the blue region of the fluorescent spectrum. He also noted that the fluorescence of lenses of female subjects, and, to a less degree, that of the lenses of male subjects, varied with the season, being higher in summer than in winter.

Klang thought that the increase of fluorescence with age could not be accounted for on the basis of increased absorption of the lens, since as early as 25 years of age the absorption at 365 mμ is 99.9%. However, the accuracy of this value is not certain; it is possible that there is a relationship between the changes with age in fluorescence and in absorption.

The appearance to the subject of the fluorescence of his own lens has been described by Goodeve [47] and Hosoya [48] as a cloudy halo, or field, surrounding the stimulus source. Goodeve also commented on the difficulties of getting the source slit in clear focus. To focus on the slit, the eyes had to be as close as 4 in. (10 cm.). This is the result of the greater refraction of ultraviolet rays by the eye, causing "myopia"; de Groot [49] has stated that for an eye emmetropic in red light the myopia at 313 mμ is 10 D. Pinegin [50] made the same observation and used a negative lens to assist the eye in accommodation. Under these conditions the source and the fluorescent halo could be clearly distinguished. This answers the possible criticism that the visibility of ultraviolet radiation is illusory, that the sensation of light is being given by the fluorescence rather than by the ultraviolet radiation itself.

Those reports which have described the color sensations aroused by ultraviolet rays have in most cases stated it to be a gray-blue. Helmholtz [51] gave a detailed account of the color change with decreasing wave length for high and low brightnesses. Below the deep violet of 400 mμ the color turned back toward blue gradually, and eventually to the gray color characteristic of scotopic vision. Hosoya's [48] and Gaydon's [52] observations are in agreement with Helmholtz', but Goodeve found

47. Goodeve, C. F.: Vision in the Ultra-Violet, Nature, London **134**:416-417, 1934.

48. Hosoya, Y.: Fluoreszenz der einzelnen Augenmedien und Sichtbarkeit des ultravioletten Gebietes des Spektrums, Tohoku J. Exper. Med. **13**:524-538, 1929.

49. de Groot, W.: Vision in the Ultra-Violet, Nature, London **135**:68-69, 1935.

50. Pinegin, N. I.: Über die absolute Empfindlichkeit des Auges im ultravioletten und im sichtbaren Spektrum, Compt. rend. Acad. sc. URSS **30**:206-211, 1941.

51. Helmholtz, H.: Treatise on Physiological Optics, translated from the third German edition, and edited by J. P. C. Southall, Ithaca, N. Y., Optical Society of America, 1924, Vol. 2.

52. Gaydon, A. G.: Color Sensations Produced by Ultraviolet Light, Proc. Phys. Soc. **50**:714-720, 1938.

that all wave lengths at 400 mμ and below appeared similar. Pinegin [50] gave the most detailed description of the color change. Since he used a mercury vapor lamp as a source, his subjects were able to compare the colors of the various lines of the mercury spectrum. The 390-mμ line appeared like the violet of 404 to 407 mμ; 365 and 334 mμ, like 435 mμ; 313 mμ, like the blue of 491 mμ, and the 302-mμ line was a clear blue-gray.

Friedrich and Schreiber [53] found no agreement among their subjects as to the color of ultraviolet radiation, and they suggested that the reported color of ultraviolet rays was due to the presence of spectral impurities from stray light entering the optical system.

Le Grand [54] has given an explanation for the color changing back to blue for wave lengths below 400 mμ. He measured the fluorescent spectrum from sheep lenses and found that the dominant wave length was 468 mμ for exciting wave lengths of 365 and 313 mμ. This would account for the blue color of ultraviolet radiation on the basis of lens fluorescence. However, this explanation does not fit Gaydon's report of blue as the color of ultraviolet radiation. Since he was an aphakic, there was no possibility of lens fluorescence, and it is doubtful whether fluorescence from the cornea and macular pigment would have been sufficient to produce changes in color sensation.

Gaydon's observations are mostly qualitative but are of special interest, since they illustrate clearly the effect of absence of the lens on ultraviolet sensitivity. Schneider [55] has a short note on Gaydon's color sensations. When light of 365 mμ was increased in intensity, from being colorless at scotopic levels, it became violet, and then blue, giving apparently two chromatic thresholds.[55a]

SENSITIVITY OF THE EYE TO ULTRAVIOLET RADIATION

It is only recently that visual sensitivity curves have been extended into the ultraviolet region. The standard ICI curve [1c] and others [56] that appear in the literature end at 380 mμ or higher.

There are many values for the limit of the visible spectrum, but they give no indication of relative sensitivity and are somewhat variable, owing to the age differences of the subjects used and the differences in the source intensities. The values reported since 1920 are, however, in fair agreement and are given in Table 1. Since the absorption of shorter wave lengths by the lens increases with age, there is, in consequence, restriction of the limit of visibility in the ultraviolet spectrum. This restriction is discussed by de Groot.[57] General reviews of the early research on

53. Friedrich, W., and Schreiber, H.: Das Sehen des menschlichen Auges im Ultraviolett: II. Die Grenze des extrafovealen Sehens im Spektrum, Arch. ges. Physiol. **246**:790-802, 1943.

54. Le Grand, Y.: Sur la fluorescence du cristallin, Compt. rend. Acad. sc. **207**:1128-1130, 1938.

55. Schneider, E. E.: Color Phenomena in Ultraviolet Vision, Nature, London **155**:176, 1945.

55a. The following paper, which appeared after the manuscript went to press, gives additional experimental evidence and a theory to explain the change from violet to blue of wave lengths below 400 mμ: Bachem, A.: The Color of Ultraviolet Light, Am. J. Psychol. **66**:251-260, 1953.

56. Gibson, K. S., and Tyndall, E. P. T.: Visibility of Radiant Energy, National Bureau Standard Scientific Paper No. 475, 1923.

57. de Groot, W.: Seeing in the Ultra-Violet, Nature, London **134**:494, 1934.

the limit of vision in the ultraviolet region are given by Hosoya [48] and Friedrich and Schreiber.[58]

Besides these values for the limit of vision there are also a few approximate values for relative sensitivity in the ultraviolet region. The latter are presented in Table 2. These values have been transformed to log sensitivities because the sensitivity curves given later are in that form. Thus, comparisons may be made more easily.

Wawilow [59] obtained a scotopic retinal sensitivity curve by his own quantum fluctuation method. The points plotted were based upon data obtained with two subjects. The most noteworthy feature of the curve is a maximum at about 380 mμ.

TABLE 1.—*Limits of Visible Spectrum Reported Since 1920*

Author	Date	Limit, in mμ
Graham [40]	1922	313
Glaney *	1923	317
Hoffmann [38]	1927	310
Hosoya [48]	1929	310
Saidman †	1933	313
Goodeve [47]	1934	313
de Groot [57]	1934	313
Taylor ‡	1935	313
Gaydon [52]	1938	309 (aphakic)

* Glaney, A. E.: Limit of visibility in the Ultra-Violet, Am. J. Physiol. Optics **4**:145-151, 1923.
† Saidman, J.: Sur la visibilité de l'ultraviolet jusqu'à la longeur d'onde 3130, Compt. rend. Acad. sc. **196**:1537, 1933.
‡ Taylor, R. J.: Vision in the Ultra-Violet, Nature, London **35**:135, 1935.

TABLE 2.—*Sensitivity to Ultraviolet Radiation*

Author	Date	Wave Lengths	Log Sensitivity
Saidman and Dufestel *	1926	404	3.0 relative to scotopic maximum
		365	6.0 relative to scotopic maximum
Büttner †	1932	365	5.0 relative to photopic maximum
de Groot [57]	1934	365	2.2-4.5 relative to 404 mμ
		313	3.7-6.6 relative to 404 mμ
Goodeve [47]	1942	365	3.0 relative to 546 mμ

* Saidman, J., and Dufestel, L.: Sur la visibilité de la portion initiale du spectre ultraviolet, Compt. rend. Acad. sc. **182**:1173, 1926.
† Büttner, K.: Akkommodation und spektrale Dispersion des menschlichen Auges, Ztschr. ophth. Optik. **20**:35-39, 1932.

Pinegin,[60] Wald,[44] Friedrich and Schreiber,[58] Wright,[61] and the Institute of Optics at the University of Rochester [62] give the only visual sensitivity curves for

58. Friedrich, W., and Schreiber, H.: Das Sehen des menschlichen Auges im Ultraviolett: I. Die extrafovealen Schwellenwerte für 365 mμ und 546 mμ, Arch. ges. Physiol. **246**:621-632, 1943; footnote 53.

59. Wawilow, S. I.: Sensitivity of the Retina to the Ultraviolet Spectrum, Compt. rend. Acad. sc. URSS. **21**:373-375, 1938.

60. Pinegin, N. I.: Absolute Scotopic Sensitivity of the Eye in the Ultra-Violet and in the Visible Spectrum, Nature, London **155**:20-21, 1945; footnotes 35 and 50.

61. Wright, W. D.: The Visual Sensitivity of Normal and Aphakic Observers in the Ultraviolet, Ann. psychol. **50**:169-177, 1951.

62. Extension of the Scotopic Visibility Curve to 3130 A and 8000 A, Institute of Optics, University of Rochester, Bibliography of Scientific and Industrial Reports Publication Board, No. 28539; Office of Scientific Research Development, Report No. 1431, March 1, 1943.

ultraviolet wave lengths. All five investigators give scotopic curves, while photopic curves are given by the first two. For comparison, the Gibson and Tyndall [56] and the ICI luminosity curves [18] are given with the photopic curves of Pinegin and Wald in Figure 3. The most recent scotopic sensitivity curves have been reported by Crawford [63] and Weaver.[64] They are included with the others in Figure 4. Wright's curve

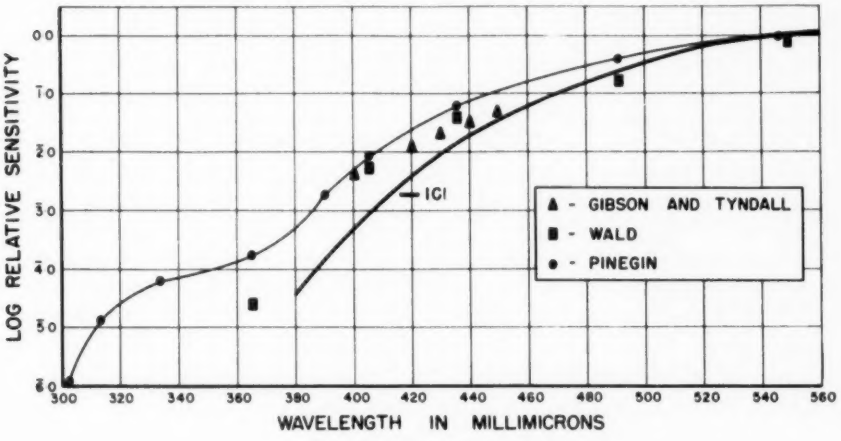


Chart 3.—Photopic sensitivity.

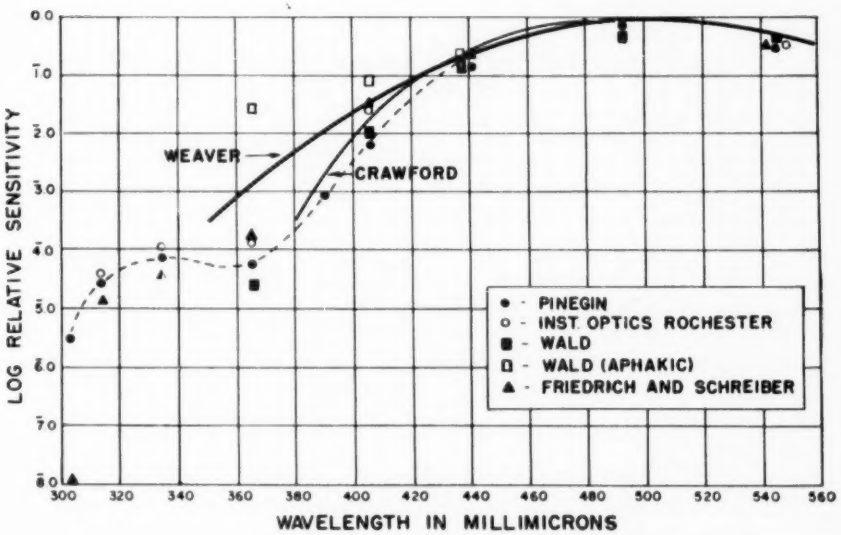


Chart 4.—Scotopic sensitivity.

is not included, as it corresponds very closely to Wald's. All values have been transformed to log relative sensitivities.

63. Crawford, B. H.: The Scotopic Visibility Function, Proc. Phys. Soc. **62**:312-334, 1949.

64. Weaver, K. S.: A Provisional Standard Observer for Low-Level Photometry, J. Optic. Soc. America **39**:278-291, 1949.

The differences in the curves are probably due in part to the different age ranges of subjects, since sensitivity to ultraviolet rays will be affected by lens absorption, which varies with age. Pinegin [59] measured absolute thresholds on nine subjects of ages ranging from 17 to 60. Friedrich and Schreiber's curve is taken from the mean threshold for his 26 subjects, who were between 17 and 30 years of age. Wald had 46 subjects, of ages unspecified, 22 normal and 24 aphakic. The Institute of Optics had four subjects, between 20 and 25 years of age. Wright [61] used 6 aphakic and 10 normal subjects, between the ages of 16 and 48. All experiments used the bright lines of the spectrum from a mercury vapor lamp. All but Wald isolated these wave lengths by spectral dispersion, while Wald had selective filters.

As suggested by Wald,[44] some of the differences in the photopic curves at the violet end may be attributed to differences in macular pigmentation. The scotopic curves are in better agreement. An interesting feature of those which extend farthest into the ultraviolet region is their appearing to flatten at about 340 mμ. This is most noticeable in Pinegin's curve, and he has suggested that it may be due to selective transmission by the lens. This is unlikely in view of the fact that Wald [65] has demonstrated three absorption bands for rhodopsin—the protein one

TABLE 3.—*Absolute Sensitivity* to Radiation at 365 and 546 Mμ*

Author	Threshold in Ergs/Sec./Cm.²	
	365 mμ	546 mμ
Pinegin [59]	3.33×10^{-5}	5.28×10^{-9}
Gurevitch and Samsonova †	6.80×10^{-5}	.....
Friedrich and Schreiber [58]	9.17×10^{-4}	2.28×10^{-9}

* Hecht (Hecht, S.: Energy Relations in Vision, in Visual Mechanisms, edited by H. Kluver, Biological Symposia, Vol. VII, Lancaster, Pa., Jaques Cattell Press, 1942, pp. 1-21) gives for 510 mμ 2.1 to 5.7×10^{-10} ergs/sec./cm.²

† Gurevitch, M., and Samsonova, V. G.: Sensitivity of the Human Eye to Ultraviolet Radiation of 365 mμ, Probl. fiziol. optiki. **2**:42-53, 1941; Psychol. Abstr. No. 677, 1946.

at 278 mμ, the band at 500 mμ, corresponding to the scotopic maximum, and a small one, at 350 mμ. It is probable that it is the last absorption band that is being reflected in the shape of the sensitivity curve.

Since only relative sensitivity is shown in Figures 3 and 4, it is interesting to compare some of the absolute values given for the scotopic threshold. As can be seen in Table 3, those figures are of the same order.

Friedrich and Schreiber also measured the light threshold for form vision for 365 and 546 mμ. Their results showed that the eye is 10,000 to 1,000,000 times less sensitive in the ultraviolet region.

SUMMARY

The effects of ultraviolet radiation (300 to 400 mμ) on visual functions are discussed. In youth, the human eye is reported to be sensitive to wave lengths down to 300 mμ, but the limit of the visible spectrum is higher in old age, owing to the increased absorption of the lens. Differences in lens absorption also lead to wide individual differences in sensitivity to ultraviolet radiation, but there are no data for the absorption of the human eye in the ultraviolet region of the spectrum.

65. Wald, G.: The Photochemical Basis of Rod Vision, J. Optic. Soc. America **41**:949-956, 1951.

It has been claimed that exposure to ultraviolet radiation will impair dark adaptation, but the weight of the evidence is against this view. Wave lengths above 305 mμ have no abiotic effect; consequently, any changes in the threshold would seem to be due to the light adaptation of the eye.

Under the action of ultraviolet rays, the lens will fluoresce strongly, and the intensity of the fluorescence increases with age. Little or nothing is known of the effect of fluorescence on visual function. There is disagreement about the color sensation produced by ultraviolet radiation, but in most cases it is stated to be blue or blue-violet.

Annual Reviews

GLAUCOMA

A Review of the Literature for 1952-1953

JOSEPH S. HAAS, M.D.
CHICAGO

TABLE OF CONTENTS

I. The Primary Glaucomas
A. Classification
B. Mechanism
1. Narrow-angle glaucoma
(*a*) Primary angle-block
(*b*) Primary vascular mechanism
2. Wide-angle glaucoma
(*a*) Hypersecretion
(*b*) Aqueous retention
(1) The hypothalamic region
(2) The parasympathetic system
(3) The sympathetic system
(4) The canal of Schlemm
(5) The aqueous veins
3. Low-tension glaucoma
C. Diagnosis
1. General considerations
2. Tonometry
3. Provocative tests
(*a*) The dark-room test
(*b*) The water-drinking test
4. Tonography
5. Perimetry
D. Medical treatment of glaucoma
1. The miotics
(*a*) General considerations
(*b*) The cholinergic drugs
(1) Pilocarpine
(2) Bethanechol (Urecholine)
(3) Acetylcholine
(4) Mintacol
(*c*) The anticholinesterase drugs
(1) Diisopropyl fluorphosphate
2. The mydriatics
3. The sympatholytic drugs
4. Hormonal therapy
5. Miscellaneous treatment
E. Surgical treatment of glaucoma
1. General considerations
2. Iridencleisis
3. Trephination and anterior sclerectomy
4. Cyclodiathermy
5. Cyclodialysis
6. Combined operations
II. Congenital Glaucoma
III. Secondary Glaucoma

Dr. Harold G. Scheie formulated the classification utilized in this paper. Dr. A. Jehanin prepared the translations from the French.

A REVIEW should be entirely impartial and a true interpretation of the material included. The reviewer, realizing that his personal beliefs may influence this interpretation, has attempted to divorce these beliefs as completely as possible. He can only hope that when this has not been possible his effort will be accepted in the same sense of humility with which it is put forth.

The year 1952-1953 has not revealed any radical change in current ideas pertaining to glaucoma. Rather, it has been a year of refinement, during which most of the reported work has helped to clarify and strengthen concepts which had previously been advanced.

I. THE PRIMARY GLAUCOMAS

A. Classification

It has been customary to present the primary glaucomas as a single entity, not because existing evidence supported this concept but, more probably, because the lack of evidence was not sufficient to subtype the diseases included therein. Recently, certain peculiarities of the acute form (known under the synonyms of acute and chronic narrow-angle glaucoma, or acute and chronic congestive glaucoma when not preceded by long-standing chronic glaucoma) seem to isolate it from the more chronic form of glaucoma (known under the synonyms of chronic wide- or open-angle glaucoma, glaucoma simplex, or chronic compensated glaucoma). A considerable amount of evidence to support this distinction has been appearing in the past year.

Rosengren [1] presents a rebuttal of Duke-Elder's [2] Proctor lecture, in which he states:

> It has long been the practice to distinguish between acute and simple glaucoma. Acute glaucoma is characterized in typical cases by, initially, short prodromal attacks with pressure rise, slight injection of the ocular vessels, and clouded vision due to edema of the cornea. Between the attacks the eye remains, for a time, normal. Ultimately, however, a severe attack occurs which more or less completely extinguishes the vision, or the disease passes into a chronic stage with continued hypernormal pressure, dilation of the ocular vessels, and eventual amaurosis.
>
> In simple glaucoma, on the other hand, no dilation of the ocular vessels appears in the earlier stages. The disease is characterized by persistent, as a rule moderate, increase in pressure and the main objective symptom is excavation of the papilla with consequent functional deterioration. Only at a later stage may a certain vasodilation also appear.

Rosengren further refines this distinction by establishing the fact that in those cases in which the angle is exceptionally shallow the disease is found to have the character of acute glaucoma. In only a few cases was simple glaucoma present.

Miller,[3] of the glaucoma clinic of the Institute of Ophthalmology in London, also discusses the apparent difference between these two forms of glaucoma. His descriptions closely parallel those of Rosengren, and he states that a study of the intraocular pressure and its variations leads one to suspect that the difference between the two groups is fundamental. Miller feels that the skepticism of this distinction stems from the fact that in the late stages of either disease the clinical features are barely distinguishable.

In addition, there is rapidly accumulating a fund of experimental data to reinforce these observations. Not the least of these are the observations on outflow phenomena made by Grant and reported in previous reviews on this subject.

Dobree,[4] in a series of normal patients and patients with narrow- and wide-angle glaucoma in whom the tensions were only moderately elevated, studied the changes in the caliber of episcleral arteries, veins, and capillaries during the diurnal fluctuations in tension. He found that a vasodilation, affecting mainly the venous

1. Rosengren, B.: The Etiology of Acute Glaucoma, Am. J. Ophth. **36**:488, 1953.

2. Duke-Elder, S.: Phasic Variations in Ocular Tensions in Primary Glaucoma, Am. J. Ophth. **35**:1, 1952.

3. Miller, S. J. H.: Intra-Ocular Pressure in Primary Congestive Glaucoma, Brit. J. Ophth. **37**:1, 1953.

4. Dobree, J. H.: Vascular Changes That Occur During the Phasic Variations of Tension in Chronic Glaucoma, Brit. J. Ophth. **37**:293, 1953.

side of the circulation, was associated with the lowest tension level and, conversely, that when the tension was raised the vessels were relatively constricted. In acute congestive glaucoma quite different changes in the vessels were observed. First, these seemed much influenced by local vascular changes and were usually unilateral. Second, the vascularity was related to the intraocular pressure, and some increased vascularity was always present at the highest point of tension. Third, the arteries as well as the veins were dilated. Dobree also noted an increased resistance to outflow in these cases of congestive narrow-angle glaucoma and concludes that the changes in these cases could be explained by an actual angle block, shutting off the anterior chamber from the canal of Schlemm, during the increased phase of tension.

The probability of a difference in vascular response between the two forms is also discussed by Ascher,[5] who believes that aqueous veins are less frequent in eyes with chronic simple glaucoma, that they are on the average smaller, and that their current is less vigorous. In acute congestive glaucoma it is more difficult to find aqueous veins.

The response of the two forms of glaucoma to the fluorescein test apparently differs. Langley and MacDonald[6] demonstrated that in glaucoma simplex the fluorescein concentration fell at a normal rate, whereas in congestive glaucoma, with a high intraocular pressure, the curve became a straight line.

Finally, Miller[7] revealed the marked difference in response of the two forms of glaucoma to the stellate-ganglion block. In wide-angle glaucoma there was only a slight fall in intraocular tension, but the narrow-angle glaucomas showed a dramatic drop unless there was an organic obstruction to the angle (synechiae). Miller was not sure whether the fall in acute congestive glaucoma was due to the pupillary effect or to a lowered venous pressure in the exit veins, due to their dilation.

Believing that this division simplifies the discussion of glaucoma, I shall continue to use such a distinction throughout this review.

B. Mechanism

1. *Narrow-Angle Glaucoma.*—Although most observers are content to accept the clinical differentiation of congestive and chronic simple glaucoma, there still exists a strong difference of opinion as to the pathogenesis of congestive (narrow-angle) glaucoma. One group, commonly referred to as the mechanical school, feels that the iris root blocks the trabeculum before the elevation of intraocular pressure and vascular congestion occur. The other group believes that the iris-root block is secondary and that the tension and congestion occur first. This group is usually referred to as the neurovascular school. Thus, a further subgrouping of the congestive glaucomas is added to facilitate the discussion.

(*a*) Articles Supporting a Primary Iris-Root Block: Barkan,[8] the originator of the gonioscopic classification of glaucoma, supports his concept by reporting an

5. Ascher, K. W.: Aqueous Veins: Their Status 11 Years After Their Detection, A. M. A. Arch. Ophth. **49**:438, 1953.

6. Langley, D., and MacDonald, R. K.: Clinical Method of Observing Changes in the Rate of Flow of Aqueous Humour in the Human Eye: II. In Glaucoma, Brit. J. Ophth. **36**:499, 1952.

7. Miller, S. J. H.: Stellate Ganglion Block in Glaucoma, Brit. J. Ophth. **37**:70, 1953.

8. Barkan, O.: Etiology of Narrow-Angle Glaucoma, Am. J. Ophth. **36**:901, 1953.

interesting case of a unilateral shallow anterior chamber. After a puncture wound of the cornea, there developed a cord of fibrous tissue between the cornea and the lens which pulled the iris-lens diaphragm forward. The patient had a typical attack of acute congestive glaucoma, which was cured by severing the cord and allowing the iris-lens diaphragm to fall back into a normal position. Barkan draws an analogy between this case of secondary glaucoma of known origin and primary glaucoma of the narrow-angle type, in which the anterior displacement of the iris-lens diaphragm and the increased seclusion of the pupil appear to be important pathogenic factors.

Ross[9] reported two classic cases of narrow-angle glaucoma in which high intraocular pressure developed during the dark-room test. During the phase of high intraocular pressure the angle gonioscopically appeared closed. Ross emphasizes, again, the belief that the elevated intraocular pressure precedes the congestion.

An interesting elaboration of the angle-block theory is presented by Posner,[10] who feels that a contact between the iris root and the internal annular ring is brought about, as has previously been suggested, by ciliary edema, pupillary dilation, etc. After the occlusion of the anterior chamber by the iris root, an annular zone of aqueous is created, which is bounded by the annular ring, the ciliary body, the trabeculum, and the periphery of the iris. The aqueous trapped in this zone is then continually absorbed until the iris root is sucked against the trabeculum everywhere. Then the tension starts to rise. Posner postulates that iridectomy works by preventing the suction in the peripheral zone and that miotics work by breaking the contact between the internal annular ring and the iris root.

Miller,[7] in his discussion of the response of narrow-angle glaucoma to stellate-ganglion block, again emphasizes the relation of the intraocular pressure to the gonioscopic picture.

(*b*) Articles Supporting a Primary Congestive Mechanism: Weekers and Prijot[11] discuss the measurement of the resistance of the aqueous flow (reciprocal of the coefficient of outflow) in congestive glaucoma. They are of the opinion that congestive glaucoma occurs when the iridocorneal angle is completely closed during the hypertensive phase.

The authors used tonography on eyes so affected for five minutes and found that in every case of congestive glaucoma the compression revealed a considerable increase in resistance during the hypertensive phase. Most interestingly, they report that the measurement of the resistance in the fellow eye, during the hypertensive phase of the glaucomatous eye, revealed in some cases a marked increase of resistance without any pathological rise in tension. This, they believe, results from a consensual phenomenon, and they conclude that the closure of the angle during the hypertensive phase in congestive glaucoma is not the primary phenomenon, but only the consequence of the uveal vascular phenomena located in the anterior segment of the eye. The presence of the consensual phenomena upholds this theory,

9. Ross, M. G.: Narrow-Angle Glaucoma, Am. J. Ophth. **36**:640, 1953.

10. Posner, A.: Suction Anterior to the Iris as a Factor in Narrow-Angle Glaucoma, Am. J. Ophth. **36**:185, 1953.

11. Weekers, R., and Prijot, E.: Measurement of the Resistance to the Aqueous Flow by the Electronic Tonometer: Results in Cases of Congestive Glaucoma Before and After Treatment, Brit. J. Ophth. **36**:511, 1952.

but the existence of this phenomenon has not been demonstrated by all observers. The reviewer has not seen this phenomenon, nor has it been seen by Grant.[12] Becker [13] has noted it in a few cases.

Goldmann,[14] by estimating the rate of flow of aqueous through the anterior chamber, found that the minute volume of flow was definitely higher than normal in cases of chronic congestive glaucoma. Gonioscopically, these cases were characterized by apparent extensive closure of the angle by the root of the iris. Since minute volume was increased, Goldmann concludes that this apparent closure was not watertight and that the increased minute volume was probably related to the vascular reaction characteristic of congestive glaucoma.

Weinstein [15] states that the origin of acute glaucoma is based on sympathetic irritation, the center of which is in the diencephalon, because he found that the blood pressure in the arm on the side of the affected eye is raised during the attack but the accommodation is unaltered, ruling out the parasympathetic system.

He also believes that the dark-room test is based on the retinal-hypophyseal neurovascular-intraocular reflex because in one case the angle appeared unchanged to gonioscopic study made before and after a positive test. The reviewer has also noticed this phenomenon but has attributed it to the miosis occurring as a result of the gonioscopic light.

Urrets and Zavalia,[16] in a philosophical discussion, attribute both noncongestive and congestive glaucoma to a specific type of progressive sclerosis which results in anoxemia of the cells and imperfect reentry into the venous circulation. In the basic, or noncongestive, type, the posterior uveal and retinal vessels are primarily involved. In the congestive type, the anterior uveal vessels are principally affected, and a tendency to plasmoid aqueous results, which may be ascribed to a disturbance of the ciliary body. These authors feel that the classification of glaucoma into narrow- and wide-angle types, although serving a useful purpose, must not be taken too literally.

2. *Wide-Angle Glaucoma.*—In general, it may be said that the etiology of wide-angle glaucoma is unknown. As a result of the recently acquired ability to study inflow and outflow phenomena, most observers favor the retention theory to explain the elevation of intraocular pressure. Nevertheless, the mechanism or site of this physiological alteration remains obscure.

(*a*) Hypersecretion: This factor has not been advocated as a cause of primary glaucoma in this year's literature.

(*b*) Retention: (1) Hypothalamic region. Arstikaitis and Hodgson [17] studied patients after lobotomy in which the frontothalamic fibers were cut and found no

12. Grant, W. M.: Personal communication to the author.

13. Becker, B.: Personal communication to the author.

14. Goldmann, H.: The Mode of Action of the Iridectomy in Chronic Congestive Glaucoma, Ophthalmologica **123**:202, 1952.

15. Weinstein, P.: Clinical Data Concerning the Central Origin of Glaucomatous Attacks, Am. J. Ophth. **36**:361, 1953.

16. Urrets, A., and Zavalia, H.: Notes on the Pathogenesis of Glaucoma, Ann. ocul. **185**:701, 1952.

17. Arstikaitis, M., and Hodgson, H.: The Effect of Lobotomy and Electroshock on Intraocular Pressure, Am. J. Ophth. **35**:1625, 1952.

definite changes in the direction either of raised or of lowered tension. They are of the opinion that the maintenance of normal intraocular pressure does not depend upon the integrity of the frontothalamic fibers.

(2) Parasympathetic system. Since the third cranial nerve carries the parasympathetic supply to the intraocular musculature, it is logical to determine whether it is responsible for the cholinergic control of the intraocular circulation. Greaves and Perkins [18] demonstrated that section of the third nerve in rabbits had no significant effect on the intraocular pressure. Stimulation of the nerve after paralysis of the extraocular muscles by decamethonium iodide caused no change in intraocular pressure. If parasympathetic fibers are responsible for the diminished outflow, the site of the lesion must be peripheral to the third nerve.

(3) Sympathetic system. After section of the cervical sympathetic fibers in cats, Greaves and Perkins [19] found little effect on the intraocular pressure. Stimulation of the cut nerve caused an initial rise, followed by a fall, in intraocular pressure. The initial rise was probably caused by a contraction of the smooth muscle in the orbit. The fall in pressure seemed due to an increased drainage of aqueous into the aqueous veins.

In this experiment the authors also demonstrated, through an ingenious method, that drainage of the aqueous from the anterior chamber is confined to the episcleral circulation and that drainage into the choroidal circulation, if it occurs at all, is minimal. It also seemed probable that, apart from some effect on the choriocapillaris, the sympathetic system does little to control the choroidal blood vessels.

(4) Canal of Schlemm. Jasuhara [20] confirms Kronfeld's observation that the canal of Schlemm does not seem to fill with blood in eyes with chronic glaucoma after a sudden reduction in intraocular pressure, although this phenomenon occurs regularly in normal eyes. This observation is somewhat indicative of a block peripheral to the trabeculum.

(5) Aqueous veins. Ascher,[5] in a spendid paper, reviews his work with the aqueous veins. He favors the retention theory of wide-angle glaucoma and suspects that the pathology is located in the outlets to the canal of Schlemm. He presents his reasons for this belief.

Ashton [21] graphically illustrates the aqueous-vein concept with a neoprene cast of a pure aqueous vein. Microdissection of the cast showed that the pure aqueous vein did not itself branch out of the canal but communicated with it directly via three channels. The connecting branches communicated with each other at their origin through a large varicose vessel of the deep scleral plexus. Ashton concluded that whether or not a vessel contains aqueous or blood or a mixture of aqueous and blood is to a certain extent fortuitous, in that its content depends upon the aqueous

18. Greaves, D. P., and Perkins, E. S.: Influence of the Third Cranial Nerve on Intra-Ocular Pressure, Brit. J. Ophth. **37**:54, 1953.

19. Greaves, D. P., and Perkins, E. S.: Influence of the Sympathetic Nervous System on the Intra-Ocular Pressure and Vascular Circulation of the Eye, Brit. J. Ophth. **36**:258, 1952.

20. Jasuhara, O.: Gonioscopic Study of Schlemm's Canal After Compression of the Eyeball, Acta Soc. ophth. jap. **56**:905, 1952.

21. Ashton, N.: Anatomical Study of Schlemm's Canal and Aqueous Veins by Means of Neoprene Casts: II. Aqueous Veins, Brit. J. Ophth. **36**:265, 1952.

inflow permitted by the almost limitless variation and minute anastomotic connections between Schlemm's canal and the superficial vessels, and upon the opposing venous blood pressure within the receiving vascular bed.

The theory that the left eye may be more susceptable to glaucoma because of the longer course of the left innominate vein is reviewed by Ascher and Spurgeon.[22]

Allergy as a factor in intraocular pressure was investigated by Böke,[23] who examined four patients during an allergic phase and found no change in tension. A patient with known chronic glaucoma had a marked decrease in the intraocular pressure during an allergic attack to milk.

3. *Low-Tension Glaucoma.*—Sjögren [24] discussess the literature and theories of causation and presents four cases in which encephalography showed pronounced cerebral atrophy. He concludes that glaucoma simplex and glaucoma without hypertension are the same disease and that they are caused by circulation defects of the same kind as those which lead to cerebral atrophy.

In an equally pessimistic report, Bloomfield [25] suggests, after studying the results of operations on eight eyes, that surgery is not significantly helpful in preventing further deterioration of visual function in this condition.

C. Diagnosis

1. *General Considerations.*—The necessity for early diagnosis is emphasized by Braley,[26] who states that 1 of every 40 persons past the age of 40 years has undiagnosed chronic simple glaucoma. Routine tonometry seems too fundamental to mention.

Franceschetti and associates [27] report a case of chronic simple glaucoma and a pituitary tumor. The diagnosis was made from the nature of the fields, which were not characteristic of glaucoma. The reviewer has seen two similar cases.

Electroretinography [28] gives a normal response in chronic and secondary glaucoma unless there is degeneration of the retina. In congestive glaucoma the a and b waves are usually increased, according to François.

Dark adaptation was studied by Monjé,[29] who concludes that increased intraocular pressure does not impair light sense. The decreased dark adaptation in glaucoma is caused by the constricted field and narrow pupil.

McDonald [30] describes a light-weight, hand-held gonioscope made with the Haag-Streit binocular.

---

22. Ascher, K. W., and Spurgeon, W. M.: Is There any Predilection of Left Eyes for Glaucoma? Am. J. Ophth. **35**:1480, 1952.

23. Böke, W.: Allergy and the Intraocular Pressure, Klin. Monatsbl. Augenh. **120**:488, 1952.

24. Sjögren, H.: The Nature of Pseudo-Glaucoma, Tr. Ophth. Soc. New Zealand **6**:14, 1952.

25. Bloomfield, S.: The Results of Surgery for Low Tension Glaucoma, Am. J. Ophth. **36**:1067, 1953.

26. Braley, A. E.: Medical Responsibility to the Glaucoma Patient, J. Iowa M. Soc **42**:519, 1952.

27. Franceschetti, A.; Forni, S., and Kessel, F.: Chronic Simple Glaucoma with Homonomous Left Hemianopsia Because of a Pituitary Tumor, Ann. ocul. **185**:996, 1952.

28. François, J.: Electroretinography in Glaucoma, Ann. ocul. **185**:993, 1952.

29. Monjé, M.: Dark Adaptation in Glaucoma, Klin. Monatsbl. Augenh. **121**:199, 1952.

30. McDonald, P. R.: Modified Binocular Gonioscope, Am. J. Ophth. **35**:1499, 1952.

2. *Tonometry.*—The normal ocular tension ranges from 10 to 30 mm. Hg (Schiøtz) with a 7.5-gm. weight, according to Glees,[31] who statistically analyzed 2,500 cases.

Using Friedenwald's tables, Kleinert [32] found that the scleral rigidity coefficient rose when the pressure rose during the normal diurnal variations, and vice versa. Such a relationship was not present when the intraocular pressure was artificially induced. He concluded that the changes in the rigidity were not sequelae of the increased intraocular pressure.

3. *Provocative Tests.*—Leydhecker,[33] in discussing provocative tests, states that the lability test was usually positive in the ascending phase and negative in the descending phase. He found that only 12 to 15% of glaucomatous eyes gave a positive result and was of the opinion that the ice-water portion of the test added nothing. The result of the water-drinking test was positive in 40% of glaucomatous eyes and was independent of the phase. The same authors mentions the use of a new drug, Vasculat (butyl Sympatol),[34] which dilates peripheral vessels, especially capillaries. When it is injected subconjunctivally into normal eyes, the pressure remains unchanged or rises only slightly (as much as 9 mm.). Eighty per cent of the glaucomatous eyes which were examined responded with a rise in pressure of more than 12 mm.

Haas [35] discusses the use of the provocative tests in the differential diagnosis of the primary glaucomas.

(*a*) The Dark-Room Test: Leydhecker [33] and Haas [35] repeat the observation that this test is effective only in narrow-angle glaucoma. Kozakiewicz [36] found that closing the eyes in a dark room for 40 to 60 minutes raised the tension in only a few cases of narrow-angle glaucoma if no cocaine was used, but if the eyes were kept open in the dark room the tension was raised in 20 to 25% of the cases.

The theory that the dark-room test is motivated by the action of light on the neurovegetative system is again propounded by Francesco.[37]

(*b*) The Water-Drinking Test and the Coffee Test: Kolb [38] used 45 gm. of caffeine-free coffee on 83 glaucomatous patients and found that none of them experienced a rise in intraocular pressure. Caffeine caused a minimal and infrequent rise. He concluded that drinking 1 liter of water proved to be the most reliable test.

---

31. Glees, N.: Statistical Calculations of the Normal Ocular Tension, von Graefes Arch. Ophth. **153**:356, 1952.

32. Kleinert, H.: Tension and Rigidity of the Eye, Klin. Monatsbl. Augenh. **122**:51, 1953.

33. Leydhecker, W.: The Use of Provocative Tests for Analyzing Functional Disturbances in Glaucoma, Klin. Monatsbl. Augenh. **121**:174, 1952.

34. Leydhecker, W.: The Treatment of Glaucoma with Vasculat, Klin. Monatsbl. Augenh. **121**:513, 1952.

35. Haas, J. S.: Provocative Tests in Primary Glaucoma, Eye, Ear, Nose & Throat Month. **32**:255, 1953.

36. Kozakiewicz, A.: Provocative Tests in Glaucoma and the Intraocular Tension in the Eye with Filtering Scars, Klin. oczna **22**:103, 1952.

37. Francesco, S.: Variations in Ocular Tension in Relation to Conditions of Illumination, Ann. ottal. e. clin. ocul. **78**:625, 1952.

38. Kolb, H.: The Effect of Coffee and of Water on the Glaucomatous Eye, Klin. Monatsbl. Augenh. **121**:524, 1952.

4. *Tonography.*—The history and the development of tonography, as well as its theoretical background, are discussed by Kronfeld,[39] who found the normal coefficient of outflow to be between 0.14 and 0.56, whereas in 34 glaucomatous eyes the coefficient was between 0.026 and 0.182, revealing considerable overlapping. This is to be expected in a slowly progressive disease with mild onset.

Knighton and deRoeth [40] also found the normal facility of aqueous outflow to be 0.1 to 0.523 cu. mm. per minute. In 48 glaucomatous eyes the average facility was 0.101 cu. mm. per minute. They concluded that tonography was another provocative test that should be used only in addition to the older diagnostic tests.

By applying a 50-gm. weight to the eye for 10 minutes, Keiu [41] found that in all normal eyes the tension was below 7 mm. at the end of the test. Tension in the glaucomatous eyes ranged from 7.9 to 33 mm. Hg. He also elicited the blind spot at the end of the test and found that it more than doubled in the glaucomatous eyes, while the enlargement was very slight in normal eyes.

5. *Perimetry.*—In a discussion of the vascular origin of field defects, Dubois-Poulsen [42] makes the observation that postoperative field loss is commoner in procedures with maximal iris trauma. They found vasodilators helpful in preventing this loss.

Simulated field loss often causes concern as to the true nature of the field changes. Day [43] emphasizes that these changes may be due to ciliary spasm caused by miotics in nonpresbyopic patients, variable pupillary size, or nuclear sclerosis or other lens changes, as well as glaucoma.

Radzikhovski [44] injects 0.75 ml. of saline under the conjunctiva to produce an increase in the vertical diameter of the blind spot. In normal eyes this diameter increases to 7 or 10 degrees, but in glaucoma, to from 11 to 25 degrees. The enlargement of the scotoma starts in 7 or 12 minutes and disappears 20 to 30 minutes later. A discussion of the mechanism accompanies the article.

D. Medical Treatment of Glaucoma

1. *The Miotics.*—(*a*) General Considerations: The rationale for the proper use of miotics in chronic glaucoma is revealed in a concise and illuminating fashion by Swan.[45] The article classifies the various drugs, discusses their mode of action, and records the author's experience with them. It should be read in its entirety.

(*b*) The Cholinergic Drugs: (1) Pilocarpine. It is Swan's feeling that pilocarpine is the drug of choice in chronic glaucoma. After the administration of large doses of pilocarpine there may be periods of slight mydriasis. This effect may explain the occasional secondary rise in tension following the control of acute glaucoma with pilocarpine.

---

39. Kronfeld, P. C.: Tonography, A. M. A. Arch. Ophth. **48**:393, 1952.

40. Knighton, W. S., and deRoeth, A., Jr.: Clinical Evaluation of the Aqueous-Flow Test: Preliminary Report, A. M. A. Arch. Ophth. **48**:148, 1952.

41. Keiu, S.: The Early Diagnosis of Glaucoma, Acta Soc. ophth. jap. **56**:933, 1952.

42. Dubois-Poulsen, A.: Visual Field in Chronic Glaucoma, Ann. ocul. **185**:673, 1952.

43. Day, R. M.: Simulated Progression of Visual Field Defects in Glaucoma, A. M. A. Arch. Ophth. **50**:255, 1953.

44. Radzikhovski, B.: The Subconjunctival Injection of Saline for a Scotometric Test in the Diagnosis of Glaucoma, Vestnik oftal. **31**:17, 1952.

45. Swan, K.: Miotic Therapy of Chronic Glaucoma—Changing Trends, A. M. A. Arch. Ophth. **49**:419, 1953.

More persistent absorption can be obtained by adding methylcellulose (4,000-centipoise type) to the solution to make a 0.5 to 1% concentration. A 3% solution of pilocarpine is generally considered the maximal concentration which is consistently effective.

The action of pilocarpine is thought by Prijot and Weekers [46] to be due to an increased drainage in the venous outflow through the scleral plexus, resulting in a significant drop in resistance to aqueous outflow.

(2) Bethanecol (Urecholine) chloride,[47] in 1% concentration, is an effective and safe miotic, which might possibly be useful as a substitute for 0.5% pilocarpine nitrate or 0.75% carbachol U. S. P. (Carcholin) in chronic glaucoma.

(3) Acetylcholine-like drugs. The efficacy of these drugs in acute glaucoma is reaffirmed by Thomas and associates,[48] who injected 0.2 gm. of acetylcholine subconjunctivally and resolved acute glaucoma in five cases.

(4) Mintacol. Hoorens and Piette [49] recommend Mintacol (a phosphoric acid compound) as an effective counteragent for atropine, stating that 2 drops of a 1:6,000 solution gives pupillary contraction and restoration of accommodation in 30 to 45 minutes.

(*c*) The Anticholinesterase Drugs: (1) Diisopropyl fluorophosphate. Leopold and Cleveland [50] summarize the advantages and disadvantages of weak (0.01%) solutions of diisopropyl fluorophosphate. Perhaps the greatest disadvantage of this drug is the rapidity with which tolerance develops. Swan [45] recommends the use of diisopropyl fluorophosphate in aphakic glaucoma in an attempt to rupture newly formed peripheral anterior synechiae.

2. *The Mydriatics.*—Sédan and Sédan-Bauby [51] and Heydenreich [52] advocate the use of atropine for the relief of pain in absolute glaucoma.

3. *The Sympatholytic Drugs.*—(*a*) Dibenamine: Neidermeier [53] obtained good, but only temporary, results with use of Dibenamine in four patients with inflammatory glaucoma.

(*b*) The methonium compounds. These ganglion-blocking compounds produce a pronounced fall in blood pressure, as well as in intraocular pressure, in patients with benign arterial hypertension and chronic glaucoma.[54]

---

46. Prijot, E., and Weekers, R.: Measurement of the Resistance to Aqueous Outflow by Means of the Electronic Tonometer: IV. The Mode of Action of Pilocarpine in Chronic Noncongestive Glaucoma, Ophthalmologica **124**:12, 1952.

47. Frisch, F., and Leopold, I. H.: Evaluation of the Urethane of Beta-Methylcholine Chloride in Chronic Glaucoma, Am. J. Ophth. **36**:442, 1953.

48. Thomas, C.; Cordier, J.; Algan, B., and Vitte, G.: Medical Treatment of Acute Glaucoma, Bull. Soc. opht. France **3**:286, 1952.

49. Hoorens, M., and Piette: Contributions to the Study of a New Miotio, Mintocal, Ann. ocul. **186**:260, 1953.

50. Leopold, I. H., and Cleveland, A. F.: Di-Isopropyl Fluorosphosphate (DFP) (0.01 per cent) in Chronic Wide-Angle Glaucoma, Am. J. Ophth. **36**:226, 1953.

51. Sédan, J., and Sédan-Bauby, S.: The Instillation of Atropine in Absolute Glaucoma, Ann. ocul. **185**:734, 1952.

52. Heydenreich, A.: Mydriatics for the Treatment of Pain in Absolute Glaucoma, Klin. Monatsbl. Augenh. **121**:168, 1952.

53. Neidermeier, S.: Dibenamine in Therapy of Inflamatory Glaucoma, Klin. Monatsbl. Augenh. **120**:534, 1952.

54. Cameron, A. J., and Burn, R. A.: Hexamethonium and Glaucoma, Brit. J. Ophth. **36**:482, 1952. Barnett, A. J.: Ocular Effects of Methonium Compounds, ibid. **36**:593, 1952.

4. *Hormonal Therapy.*—Treumer [55] treated 30 forms of glaucoma with the corpus luteum hormone (progesterone) and found no effect, whereas in a very heterogeneous group of glaucomas Posthumus [56] observed a slight to marked lowering of the ocular tension after the subcutaneous or intramuscular implantation of a progesterone preparation.

5. *Miscellaneous Treatment.*—Hyaluronidase given locally controlled the intraocular pressure in two cases of post-traumatic hypertension, as reported by Albrousse.[57]

E. Surgical Treatment of Glaucoma

1. *General Considerations.*—The tendency of some ophthalmic surgeons to operate for chronic simple glaucoma as soon as the tension is above 30 mm., in spite of normal ocular function, is strongly condemned by Redslob.[58]

The effect of cortisone in filtering operations was investigated by Laval and Coles.[59] It is their opinion that subconjunctival administration of cortisone only slightly depressed healing but that the intramuscular injection of cortisone for three days prior to the operation and every day thereafter decidedly retarded healing. Their dosage recommendations are included in their paper.

Parry [60] presents a clever device for postoperative massage in filtering operations. It should appeal to all who have seen the results of their well-intentioned instructions to the patient go awry.

2. *Iridencleisis.*—The mode of action of the iridencleisis is still a controversial issue. A paper supporting the filtration theory was presented by Sourdille,[61] who found in 446 cases that, on the whole, good results were generally accompanied by good filtration.

On the other hand, Weekers and Prijot [62] believe that iridencleisis functions by enhancing or reestablishing the function of the normal outflow. They found a permanent bleb in only one-fourth of their cases of iridencleisis for wide-angle glaucoma. These eyes were clearly fistulating, and the resistance to outflow was less than normal. In the other three-fourths the resistance to aqueous outflow was normal. The reviewer wonders whether the two authors classify blebs similarly.

---

55. Treumer, K.: The Corpus Luteum Hormone in the Treatment of Glaucoma, Klin. Monatsbl. Augenh. **120**:523, 1952.

56. Posthumus, R. G.: The Use and the Possibilities of Progesterone in the Treatment of Glaucoma, Ophthalmologica **124**:17, 1952.

57. Albrousse: Post-Traumatic Hypertony Treated by the Instillation of Hyaluronidase: Report of 2 Cases, Arch. opht. **2**:173, 1953.

58. Redslob, E.: The Surgical Procedure in Chronic Simple Glaucoma, Ann. ocul. **186**:174, 1953.

59. Laval, J., and Coles, R. S.: Role of Cortisone in Glaucoma Surgery, A. M. A. Arch. Ophth. **49**:168, 1953.

60. Parry, T. G. W.: Post-Operative Eye Massage in Cases of Glaucoma, Brit. J. Ophth. **36**:698, 1952.

61. Sourdille, G. P.: Iridencleisis and Filtration, Ann. ocul. **185**:993, 1952.

62. Weekers, R., and Prijot, E.: Measurements of the Resistance to Aqueous Outflow by Electronic Tonometry: V. The Mode of Action of the Iridencleisis in Chronic Non-Inflammatory Glaucoma, Ophthalmologica **124**:166, 1952.

3. *Sclerectomy and Trephination.*—These operations seem firmly established. Pallarés [63] presents interesting modifications of Stallard's operation.

To correct the complication of delayed re-formation of the anterior chamber, Naccache [64] passes a mattress suture across the bleb and anchors it in the sclera on each side. This suture is then pulled tight and saline injected into the anterior chamber. If the chamber stays re-formed, the suture is removed after several days.

4. *Cyclodiathermy.*—The equivocal status of cyclodiathermy is indicated by the volume of material justifying its existence. One finds a decided tendency to move the site of diathermy posteriorly so that the electrocoagulations are made 7 to 9 mm. from the limbus.

Weekers and Weekers [65] use a flat electrode, 0.75 mm. in diameter, coupled with a thermal meter, and recommend 24 applications distributed evenly over the four quadrants. Under standard procedure, a temperature of 90 C. is maintained for 15 seconds. The diathermy applications are aimed at the superciliary and suprachoroidal nerve plexuses. It is their opinion that the operation functions by decreasing aqueous formation.

Urrets-Zavalia [66] performs a similar operation and feels that the results are rather favorable. He concludes that diathermy is the operation of choice in secondary and absolute glaucoma but that the filtering operations should be used for chronic glaucoma and the iridectomies for narrow-angle glaucoma when indicated.

Neubauer [67] modifies the operation by placing surface diathermy just in front of the external rectus muscle, thereby creating a partial obliteration of the branches of the long ciliary arteries. He reports success in 63% of cases. Arato [68] does a similar procedure, using 1.5-mm. perforating electrodes. He reports no complications and believes that the operation is indicated in chronic glaucoma and as a supplementary procedure in buphthalmos and aphakic glaucoma.

In contrast, Lachman and Rockwell,[69] using the method recommended by Castroviejo, had poor results in a series of 39 cases. In six cases atrophy of the globe developed.

In a case of Bodian's [70] sympathetic ophthalmia developed three and one-half months after a surface and partially penetrating cyclodiathermy. A posterior sclerotomy was done, but Bodian concludes that this could not have caused the sympathetic

63. Pallarés, J.: Some Modifications in the Details of Stallard's Operation for Glaucoma, Arch. Soc. oftal. hispano-am. **12**:1178, 1952.

64. Naccache, R.: Delayed Re-Formation of Anterior Chamber After Trephine Operations, Brit. J. Ophth. **36**:462, 1952.

65. Weekers, L., and Weekers, R.: The Treatment of Ocular Hypertension with Retrociliary Diathermy, Ophthalmologica **124**:221, 1952.

66. Urrets-Zavalía, A., Jr., and Urreis-Zavalía, A.: Nonperforating Cyclodiathermy in the Treatment of Glaucoma, Am. J. Ophth. **36**:203, 1953.

67. Neubauer, H.: The Nonperforating Cyclodiathermy According to Grüter, Klin. Monatsbl. Augenh. **121**:9, 1952.

68. Arató, S.: Results of Angiodiathermy on the Basis of 100 Operations, Ophthalmologica **125**:117, 1953.

69. Lachman, E., and Rockwell, P. A.: Follow-Up Study of 39 Patients with Glaucoma Treated with Cyclodiathermy, A. M. A. Arch. Ophth. **50**:265, 1953.

70. Bodian, M.: Sympathetic Ophthalmia Following Cyclodiathermy, Am. J. Ophth. **36**:217, 1953.

ophthalmia, since the latter never occurs after operations for retinal detachment. He notes two other cases, and Urrets-Zavalia[66] mentions several others; but no information on the type of cyclodiathermy or the associated operations is included. If sympathetic ophthalmia occurs after nonperforating cyclodiathermy alone, this procedure should be contraindicated for blind eyes in the presence of a functioning fellow eye.

5. *Cyclodialysis.*—Three authors report a series of cases in which the cyclodialysis is done through a trephine opening. Löhlein and von Glasenapp[71] perform the trephination in the upper temporal quadrant 7 mm. from the limbus. Flieringa[72] does the trephination under one of the rectus muscles, as does Malbrán.[73] They all conclude that the cyclodialysis cleft must remain patent to insure success of the operation.

Two authors[74] recommend the insertion of a plastic tube into the cyclodialysis cleft to aid internal fistulation.

A logical explanation is offered by Goldmann[75] for the acute congestive glaucoma that often follows sudden closure of the cyclodialysis cleft. He postulates that the canal of Schlemm and the trabeculum become inactive from disuse when they are by-passed and therefore are inoperable if the supraciliary cleft closes.

6. *Combined Operations.*—Birge[76] recommends that cataract extraction and iridencleisis be combined into one operation for the patient with cataract and glaucoma who cannot stand two operations.

II. CONGENITAL GLAUCOMA

The photophobia, which is often the first symptom of congenital glaucoma, is explained as a defense reflex of the retina that interferes with adaptation. This, Stankovic and Stankovic[77] believe, is of central origin. The importance of this symptom cannot be overemphasized.

Medically, instillation of 0.25% atropine is suggested as treatment by Nonnemacher,[78] who controlled the pressure in three of six children in this way.

Barkan,[79] in a complete résumé of his work with goniotomy, states that this operation is indicated in all cases of bilateral and unilateral congenital glaucoma in which the increased pressure is due to obstruction of the angle by persistent embryonic tissue or false anterior insertion of the iris, provided that Schlemm's canal has not been obliterated by prolonged distention of the globe. His technique is reviewed.

---

71. Löhlein, H., and von Glasenapp, I.: Our Experience with Cyclodialysis Performed from a Trephine Hole, Especially with Regard to Preoperative and Postoperative Gonioscopic Findings, Klin. Monatsbl. Augenh. **122**:179, 1953.

72. Flieringa, H. J.: Cyclodialysis Combined with Posterior Trephining, Brit. J. Ophth. **36**:518, 1952.

73. Malbrán, G. J.: Submuscular Cyclodialysis, Am. J. Ophth. **36**:365, 1953.

74. (*a*) Lösche, W.: Improvement of Cyclodialysis, Klin. Monatsbl. Augenh. **121**:715, 1952. (*b*) Bietti, G. B.: Plastic Drainage in Cyclodialysis, Ateneo parmense **23**:8, 1952.

75. Goldmann, H.: The Drainage System of the Canal of Schlemm After Opening New Drainage Channels, Ophthalmologica **125**:16, 1953.

76. Birge, H. L.: The Treatment of Cataract with Glaucoma, Am. J. Ophth. **36**:925, 1953.

77. Stankovic, M., and Stankovic, I.: Contribution to the Early Symptomatology in Congenital Glaucoma: Frequency of False Photophobia, Ann. ocul. **185**:994, 1952.

78. Nonnemacher, H.: Atropine as Treatment for Infantile Glaucoma, Klin. Monatsbl. Augenh. **121**:533, 1952.

79. Barkan, O.: Present Status of Goniotomy, Am. J. Ophth. **36**:445, 1953.

Of 178 eyes, Barkan has normalized the pressure by means of goniotomy in 129, with maintenance of vision. Bietti [74b] also praises goniotomy in treatment of congenital glaucoma.

III. SECONDARY GLAUCOMA

This serious complication continues as one of our most difficult therapeutic challenges. With increasing refinements of diagnosis, i. e., tonography, gonioscopy, and fluorescein concentrations in the aqueous, the mechanisms should become better understood, and consequently the treatment should acquire a more rational basis.

A. Glaucoma Secondary to Iridocyclitis.—Kravitz [80] reiterates the importance of gonioscopy in all cases of secondary glaucoma. He feels that the glaucoma in the acute phase of iridocyclitis is due to an increased viscosity of the aqueous and that the postinflammatory phases are due to synechiae or an organization of exudates in the angle. The treatment should be related to the organic status of the angle.

B. Syndrome of Glaucomatocyclitic Crises.—Theodore [81] and Israel [82] present two reviews of the subject. Nothing new is added.

C. Glaucoma Secondary to Occlusion of the Central Retinal Artery.—This type is discussed by Benton.[83] In two histologically proved cases the disease resembled glaucoma secondary to thrombosis of the central vein. After a quiet interval of 4½ to 10 weeks, sudden, severe, painful glaucoma develops in the blind eye. Neovascularization appears on the iris and the angle is obliterated.

D. Miscellaneous Forms.—Riffenburgh [84] presents the case of a man aged 21 with a Krukenberg spindle and heavy pigmentation in one eye, with a positive water-drinking provocative test. This case may be one of early pigmentary glaucoma.

Loss of vitreous at operation was responsible for 37% of the cases of secondary glaucoma following cataract extraction in the series of Post and Harper.[85] Postoperative hyphema accounted for 14%, iridocyclitis for 14%, and delayed re-formation of the anterior chamber for 5.5%.

Scott [86] adds three cases of spontaneous rupture of the lens capsule and discusses the condition.

Weekers and Delmarcelle,[87] in an exceptionally well-studied case of glaucoma secondary to arteriovenous aneurysm, ascribe the hypertension to increased episcleral pressure.

---

80. Kravitz, D.: Study of the Anterior Angle in Anterior-Segment Inflammation of the Eye, Am. J. Ophth. **35**:1463, 1952.

81. Theodore, F. H.: Observations on Glaumatocyclitic Crises: (Posner-Schlossman Syndrome), Brit. J. Ophth. **36**:207, 1952.

82. Israel, E. B.: The Syndrome of Glaucomato-Cyclitic Crisis, South Africa M. J. **26**:809, 1952.

83. Benton, C. D., Jr.: Glaucoma Following Occlusion of the Central Retinal Artery, A. M. A. Arch. Ophth. **49**:341, 1953.

84. Riffenburgh, R. S.: Glaucoma Associated with Krukenberg's Spindle, A. M. A. Arch. Ophth. **49**:341, 1953.

85. Post, L. T., and Harper, L. B.: A Study of Glaucoma Secondary to Cataract Extraction: Based on 500 Senile Cataract Extractions, Am. J. Ophth. **36**:103, 1953.

86. Scott, J. G.: Spontaneous Rupture of the Lens Capsule, Brit. J. Ophth. **37**:58, 1953.

87. Weekers, R., and Delmarcelle, Y.: Pathogenesis of Intraocular Hypertension in Cases of Arteriovenous Aneurysm, A. M. A. Arch. Ophth. **48**:338, 1952.

In a brief, but comprehensive, review, Posner [88] relates his experiences with glaucoma secondary to thrombosis of the central vein, glaucoma associated with retinitis pigmentosa, uncomplicated aphakia, and glaucomatocyclitic crisis.

Barkan [89] suggests the use of goniotomy in glaucoma secondary to congenital aniridia and reports a successful case. Blake,[90] when confronted with a similar case, wrote to 87 ophthalmologists for their surgical preference. He received 41 replies from surgeons who had operated for this condition, and he concluded that cyclodiathermy is the operation of choice. Anterior sclerectomy had a higher incidence of success and should be favorably considered.

Rare and interesting cases associated with systemic diseases are presented by Durham,[91] Posner,[92] and Keyes and Parisi.[93]

Finally, the reviewer extends his sincere regrets to the writers of the many fine papers which either did not come to his attention or could not be included because of the lack of space.

88. Posner, A.: Borderline Forms of Glaucoma, Am. J. Ophth. **35**:1291, 1952.

89. Barkan, O.: Goniotomy for Glaucoma Associated with Aniridia, A. M. A. Arch. Ophth. **49**:1, 1953.

90. Blake, E. M.: The Surgical Treatment of Glaucoma Complicating Congenital Aniridia, Am. J. Ophth. **36**:907, 1953.

91. Durham, D. G.: Cutis Hyperelastica (Ehlers-Danlos Syndrome) with Blue Scleras, Microcornea and Glaucoma, A. M. A. Arch. Ophth. **49**:220, 1953.

92. Posner, M.: Transient Glaucoma Associated with Meningeal Hydrops, A. M. A. Arch. Ophth. **50**:189, 1953.

93. Keyes, J. E. L., and Parisi, P. J.: Malignant Exophthalmos with Glaucoma: (Clinicopathologic Case Report), Tr. Am. Acad. Ophth. **57**:177, 1953.

Correspondence

MONOCULAR APHAKIA

To the Editor:—In the July 1953 ARCHIVES (page 16) appeared an article by Dr. Alfred Cowan entitled "Monocular Aphakia." Dr. Cowan is an authority on optics, and his opinions carry great weight. My knowledge of optics is limited, but I have had considerable experience with aphakic patients. I believe a little of the other side of the picture should be presented. Dr. Cowan does not mention in his article what occurs to an eye in which the cataract is allowed to go to hypermaturity. The eye will almost always become exotropic, and this starts as convergence insufficiency, long before the cataract matures. If the eye is allowed to diverge, it will never come back into line, so that if eventually both eyes are operated on the patient will either alternate or suppress. The other unpleasant complication that occurs in eyes with hypermature cataract is secondary glaucoma, due to toxic lens substance seeping through the posterior capsule. This is a frequent and embarrassing complication to an ophthalmic surgeon who has told the patient one eye was good enough to do him the rest of his life.

Dr. Cowan states that "the aphakic eye is so different from a normal eye that elderly people seldom, if ever, are able to obtain good single binocular vision with two aphakic eyes when corrected with spectacle lenses." I have a great many patients going around perfectly happy in the belief that they are using both aphakic eyes together, although I never thought it necessary to measure the degree of stereopsis on the amblyoscope.

Dr. Cowan then states that an aphakic eye cannot possibly be paired up with a normal eye—few are entirely normal—by a spectacle lens, a minifying lens, or a contact lens. I have 10 or 12 patients wearing contact lenses over the aphakic eye whom this statement would mystify. They are all persons in the active phase of life—one is a bookkeeper; another is a construction foreman who clambers over buildings, and the others are all working at various occupations. These people all fuse the Worth dot test for near and distance, do not have diplopia, and with a bifocal lens can do bar reading; and they have a large field of vision in the aphakic eye. It is true that they have a low degree of fusion, but it suffices for their needs.

In my opinion, a cataract should be removed at or before maturity regardless of the state of the opposite eye, except in the case of old or feeble persons. It is only in these old people that the ophthalmic surgeon should fail to urge that the second cataract be removed without too long an interval between operations. We now possess a means of making the patient with monocular aphakia happy about his eyes with a contact lens—a distinct advance in ophthalmology.

EVERETT L. GOAR, M.D.
1804 Walker Ave., Houston 9, Texas.

To the Editor:—I agree with Dr. Goar that there is another side to the picture. I am also well aware of his wide experience with aphakic patients. To discuss both sides of the picture thoroughly would surely drag the matter out to a greater length than either of us might desire. And probably in the end there would remain the

same difference between the final opinions, as expressed in the last paragraph of his letter, and my statement that "if a patient already has one useful eye, whether aphakic or normal, it is not worth subjecting him to the hazard, apprehension, nervousness, and cost of an operation, then the fitting of a contact lens, besides a pair of spectacles, and, after all that, a course of training, all in order that he may obtain at best a counterfeit sort of single binocular vision."

ALFRED COWAN, M.D.
Philadelphia.

LENS REFRACTION TREE

To the Editor:—In the September 1953 issue of the ARCHIVES, page 357, Dr. Robert S. Rosner describes his "Lens Refraction Tree."

The principle of the double lorgnette for refraction was described by me in a paper entitled "Retinoscopy Simplified" *Eye, Ear, Nose & Throat Month.* **25**:254-255 (May 1946). At that time, I advised having two double lorgnettes, one with + and −0.25 lenses, and a second one, with + and −0.50 lenses. Since, I have added another one, with + and −1.00. I think it is not practical to have the crossed cylinder attached to any of these lorgnettes, as the twirling around should be done while the other lenses are before the eye. In that case, the patient may hold the lorgnette, while the examiner holds and twirls the crossed cylinder.

WERNER BAB, M.D.
350 Post St., San Francisco 8.

Society Transactions

CANADIAN OPHTHALMOLOGICAL SOCIETY

June 14-16, 1953

The 16th annual meeting of the Canadian Ophthalmological Society was held at Minaki Lodge, Minaki, Ont., June 14 to 16, 1953. The attendance was excellent and the program most interesting. Dr. E. P. Birch, of St. Paul, was the guest speaker and gave a paper on the "Safeguards in Cataract Surgery." This was a most comprehensive and carefully thought-out discussion of the subject. He dealt with it under the headings of preoperative examination, psychological and physical preparation of the patient, operative and anesthetic technique, and postoperative care and refraction.

Drs. S. T. Adams and J. R. Bourne, of Montreal, presented a paper entitled "Report of 175 Cases of Glaucoma, with Special Reference to Classification, Gonioscopy, and Tonography." They divided their cases basically into the open-angle and the closed-angle group, with subdivisions of each. In their study, there was good correlation between the tonogram and the status of the angle in the closed-angle type. They found that trephining normalizes the tonogram. They had considerable difficulty in classifying borderline cases by these means.

Drs. R. J. MacDonald and T. H. Hodgson, of Toronto, presented a report of their fundamental investigations on the aqueous flow. Their paper, entitled "Slit-Lamp Studies on the Flow of the Aqueous," described an improved method for accurately measuring changes in the concentration of fluorescein in the anterior chamber without disrupting the physiology of the eye. In these experiments, fluorescein was administered by instillation in the conjunctival sac. By slit-lamp readings the concentration in the aqueous was read at intervals, and thus the aqueous flow could be determined. They found that fluctuations in the bulk rate of flow, either spontaneous or following the instillation of a miotic, were reflected in the changes in flow in the aqueous veins, but neither the fluctuations nor the aqueous vein changes bore a constant parallel relationship to tonometric readings.

Case reports were presented on "Sympathetic Ophthalmia," by Dr. W. C. Guest, of Winnipeg, Man., on "Toxoplasmosis," by Dr. E. N. Wright, of Port Arthur, Ont. Dr. J. E. Rose, of Winnipeg, reported a case of entry of an oily ointment into the anterior chamber following a traumatic wound of the cornea.

In a paper on the "Histological Interpretation of Fundus Lesions," Dr. O. B. Richardson, of Toronto, showed several Kodachrome slides depicting the fundus picture and the histological changes in certain vascular lesions of the fundus.

Dr. J. C. Locke, of Montreal, presented a paper on "Retrolental Fibroplasia," showing in its production the definitive role of oxygen administration to the premature infant. His very careful studies presented strong evidence that the administration of a superabundance of oxygen increases the incidence of this disease.

Dr. W. W. Wright reported on "The Work of the C. N. I. B. for the Blind and for the Prevention of Blindness." A most interesting genetic study of myotonia atrophica and its ocular features was presented by Dr. J. Maciver, of Owen Sound.

Dr. B. Alexander, of Montreal, presented a complete case history, with pathological slides, of an exceedingly rare condition, astrocytoma of the retina.

Dr. J. A. MacLean, of Vancouver, B. C., reported on the results obtained in 17 cases in which the Ridley acrylic lens was used at the time of cataract extraction. He emphasized the importance of keeping the pupil mobile after operation and of proper selection of patients.

Dr. E. Powell, of Port Arthur, Ont., discussed the "Treatment of Congenital Ptosis" and presented his results in treating several patients with this disturbance. In those cases in which there is no levator action he prefers the fascia lata sling operation of Wright.

Dr. J. V. V. Nicholls, of Montreal, presented a clinical study of seven cases, representing six patients, of "Macular Edema in Association with Cataract Extraction." The clinical findings indicated that the basic cause was a vascular dysfunction of an arteriosclerotic or an arteriospastic nature, and that the precipitating cause was anxiety in some cases and prolapse of the vitreous forward through the pupil in others.

Dr. J. H. Quigley and Dr. J. F. Ballantyne, of Toronto, presented the results of a study on the "Antibiotic Sensitivities of Strains of Staphylococcus Aureus Recovered from Eye Cultures." They found in 146 cases of coagulase-producing Staph. aureus that 32.9% were sensitive to penicillin, 69.2% to chlortetracycline aureomycin, 71.2% to streptomycin, and 82.2% to chloramphenicol. Apparently, resistant strains were commoner among hospital patients.

Dr. C. H. Andrews, of Prince Albert, Sask., showed the importance of proper centering of lenses, centration being determined by the power of the lenses and, in readers, by the reserved power of convergence.

NEW YORK ACADEMY OF MEDICINE, SECTION OF OPHTHALMOLOGY

Willis S. Knighton, M.D., *Chairman*

Raymond E. Meek, M.D., *Secretary*

Regular Meeting, Dec. 15, 1952

Tropical Ophthalmology in French Cameroon, West Africa, 1951. Dr. Virginia Lubkin.

Treatment of Orbital Tumors. Dr. Algernon B. Reese.

The scope of this subject excludes certain lesions producing proptosis, such as those arising in the sinuses and nasopharynx and extending secondarily into the orbit (osteoma, mucocele, and malignant tumors). Also excluded are metastatic tumors and certain rare conditions, such as craniodysostosis and arteriovenous aneurysm. Furthermore, because of the great variety of conditions belonging in the category under discussion, it seems best to exclude the rare and straggling cases and discuss only the conditions which constitute over 90% of the lesions under discussion. These are in the order of frequency as judged by the consecutive group of cases from the Institute of Ophthalmology, as follows:

	No. of Cases
Hemangioma	65
Lymphomatous tumors	54
Chronic granulomas (pseudotumor)	45
Dermoid cyst	33
Mixed tumor of the lacrimal gland	19
Peripheral nerve tumors (neurilemmoma and neurofibroma)	15
Meningioma	14
Astrocytoma (glioma) of the optic nerve	8

[The above groups of cases were discussed from the standpoint of diagnosis.]

In dealing with these groups, we have the following choices: (1) temporization, (2) biopsy, (3) transconjunctival surgical approach (with and without the Krönlein operation), (4) Krönlein operation, (5) irradiation, (6) exenteration, and (7) transcranial surgical approach.

[The above procedures were discussed from the standpoint of indications and technique. The foregoing list of lesions were then reviewed with regard to the indications for the various procedures enumerated.]

The problem usually presents itself as follows:

(*a*) A well-demarcated, apparently encapsulated mass.

In such cases usually a Krönlein operation is indicated.

(*b*) A deep, rather indistinct mass or resistance.

In such cases the transconjunctival approach should be employed, permitting palpation of the orbit with the index finger. If the lesion is encapsulated and well localized, the Krönlein operation can then be carried out. If palpation indicates that the lesion does not lend itself to excision, at least biopsy tissue can be removed.

2. No palpable mass

(*a*) Indentation of the sclera, as shown by retinal striae. This is an accurate localizing sign and warrants the Krönlein operation for removal of a localized tumor.

(*b*) Pressure on the optic nerve, causing atrophy or papilloedema, or at least dysfunction. An exploratory transconjunctival approach is usually indicated, which permits palpation of the orbit. If a localized mass is encountered, then the Krönlein operation can be carried out.

Technique and Complications of the Krönlein Operation. Dr. Raynold N. Berke (by invitation).

The author outlined a modified Krönlein operation for orbitotomy which had been done at the Institute of Ophthalmology in 25 consecutive cases. His talk was illustrated by means of lantern slides reviewing the anatomy of the orbit and showing the individual steps of the new technique. A horizontal incision is made from the external canthus toward the temporal area, after which the lateral orbital wall is removed by means of the new Stryker vibrating saw. Several slides illustrating the results of this technique were shown, and brief mention was made of some of the operative and postoperative complications associated with this procedure, the advantages of which are a less conspicuous scar, greater exposure of the retrobulbar contents, and a simplified technique. For avoiding complications, blunt dissection was advised wherever possible, sharp dissection being used only under direct visualization and unnecessary traction on the globe being avoided.

Willis S. Knighton, M.D., *Chairman*

Raymond E. Meek, M.D., *Secretary*

Regular Meeting, Jan. 19, 1953

Observations on Blood Sludging. Dr. Isadore Givner.

To my knowledge there has been no ophthalmological article written on the subject of blood sludging. Oculists who use the slit lamp daily are in a better position to evaluate the lower grades of blood sludging, that is, to determine when it is a physiologic variation or really a pathologic abnormality. Some of the discrepancies in the literature may hinge on this factor.

In a study of 80 cases of sludged blood, the sedimentation rate was increased in 50% and normal in 50%. Cases of anxiety fell into the latter pattern. All cases in which the sedimentation rate was above 30 mm. in one hour showed unmistakable sludging.

Seven cases of patients with retinitis centralis serosa showed sludging and a type of personality that allowed for its precipitation by emotional stress.

An attempt was made to influence sludging by local instillation into the conjunctival sac. This was unsuccessful with the use of ethylmorphine hydrochloride (Dionine), cortisone, and hyaluronidase. Given systemically, salicylates and tocopherols were of no value. Patients examined one hour after the intravenous admin-

istration of procaine showed no changes in the blood sludging. Trypsin given intravenously, however, did lessen the sludge in two cases in which the drug was administered.

Ophthalmologists should take an interest in investigations for sludged blood when doing routine slit-lamp examinations.

DISCUSSION

DR. WILLIS S. KNIGHTON: It is important that we should be able to differentiate sludging of the conjunctival vessels and that of aqueous veins. Some of these pictures looked like aqueous veins, with the blood cells below and aqueous above.

DR. JAMES W. SMITH: My son stimulated my interest in this subject. He showed me papers that have appeared in surgical journals on sludging as a cause of postburn shock. I read the articles cited by Dr. Givner and was impressed by the emphasis placed on conjunctival sludging. Knisely and his co-workers, who pioneered in the study of these conjunctival changes, believe that sludging is an important factor in the production of shock. However, some authors were not in agreement. Robertson, Wolf, and Wolff reported that widespread sludging in the conjunctival vessels is compatible with good health and well-being. Laufman contended that investigators have failed to establish the delimiting factor by which sludging causes shock in some circumstances and not in others.

I should like to ask Dr. Givner whether anyone else has reported on the significance of sludging in ophthalmology. Will he kindly tell us in more detail how to diagnose sludging as a routine office procedure?

DR. ARTHUR ALEXANDER KNAPP: Allergic conjunctivitis often gives the impression of a practically normal eye so far as conjunctival injection is concerned. The few articles on sludging that I have seen and heard do not differentiate between the allergic conjunctival membrane and the normal conjunctiva. Since this differentiation is so important, I was wondering whether that had been done in this instance, and, if so, what effect allergic conjunctivitis has on sludging in the blood vessels.

DR. S. SEGAL: I should like to ask whether Dr. Givner has noticed sludging in the retinal vessels in any diseases.

DR. ISADORE GIVNER: In reply to Dr. Knighton's remark regarding the resemblance of a sludged vessel to an aqueous vein, this appearance of a settling out of the erythrocytes to the bottom of the vessel gave rise to the term "sludge," the similarity being to the sediment in a pipe settling to the bottom. That the sludged vessel is not a normal aqueous vein is shown by the similar appearance of sludge in an adjoining artery. The appearance of sludge in an aqueous vein has the same beading or segmentation as that in other vessels.

In regard to Dr. Smith's query regarding the importance of sludging, this is still an unsettled question, which I hope we ophthalmologists will be able to help answer, as we have greater opportunities of studying conjunctival vessels with a slit lamp than physicians in any other specialty. The frequency of its appearance in systemic disease is well defined by Melvin H. Knisely, Annotated Bibliography on Blood Sludge, *Post Grad. Med.* **10**:15, 1951. In the paper presented this evening, its importance in psychosomatic entities of ocular interest, such as retinitis centralis serosa, has been brought out. The fact that the patients did not have increased sedimentation rates, but had marked sludging in the conjunctival vessels, shows the part anxiety plays in this disease, as blood sludging is present in all cases of anxiety. The fact that 50% of patients studied with sludge had increased sedimentation rates is of obvious significance, the value of which is as yet undefined.

The appearance of sludging as shown in the moving pictures this evening should help in its recognition.

In answer to Dr. Knapp as to the effect of allergic conjunctivitis on blood sludging, I should say that the circulation is somewhat slowed in edema and makes for easier recognition of sludging if it is present.

In answer to Dr. Segal as to sludging in retinal vessels, the only paper on this subject that I know of is one by Polman, who found that if agglutination or segmentation occurs in three seconds or less after pressure is applied to a globe, the patient is pathologic or pregnant (Ploman, G.; Demonstration ophtalmoscopique des variations de stabilité dans la suspension des globules rouges, *Ann. D'ocul.* **157**:569, (1920).

Idiopathic Hypoparathyroidism and Cataract: Report of Four Cases. Dr. Abraham S. Haft.

Idiopathic hypoparathyroidism is called rare by nearly every author. The criteria for its diagnosis as formulated by Drake and Albright, are as follows: (1) no history of operation on the neck, (2) low serum calcium, (3) elevated serum phosphorus, (4) normal renal function, and (5) normal appearance of bones on roentgen examination. A recent critical analysis of the literature established the total number of reported cases as 52.

Four cases of idiopathic hypoparathyroidism were presented. All the patients had cataract. The literature is obscure on whether cataract may be presented in hypoparathyroidism by prophylactic means. In cases 1 and 4 the cataracts progressed after the diagnosis had been established and the patients placed under adequate treatment. In Case 1 this assumption is open to serious question. In each of the four hospital admissions of this patient subsequent to the initial diagnosis, he entered in chronic tetany. Cases 2, 3, and 4 are of especial interest, in that the finding of cataract in young, apparently well persons, led to the diagnosis of hypoparathyroidism by the ophthalmologist.

The diagnosis of hypoparathyroidism presents little difficulty if the condition is borne in mind.

Role of Cerebral Angiography in Ophthalmology. Dr. Harold H. Joy (by invitation), Syracuse, N. Y., and Dr. Arthur D. Ecker (by invitation) and Dr. Paul A. Riemenschneider (by invitation), Syracuse, N. Y.

The presence of an unexplained visual defect should always suggest the possibility of an intracranial lesion. Ophthalmologic examination may yield the first clinical sign of a pituitary tumor or aneurysm or meningioma at the base of the skull.

Since not only vision but life itself may be at stake, early diagnosis is essential. This may be extremely difficult. Helpful neurologic findings are rarely present, and plain X-rays of the skull ordinarily show few or no bone changes.

In such cases the close relationship of the visual pathways to the arteries at the base of the brain assumes particular importance. In this congested area even a small lesion impinging on the pathways tends to displace the adjacent arteries. Their conversion into radiopaque landmarks by the injection of a contrast medium provides visualization of the displacement, and sometimes of the vascular tree of the tumor itself. Moreover, it offers an unexcelled opportunity to visualize vascular anomalies, a subject which will be reserved for a later paper.

A distinct advantage of angiography over other types of diagnostic procedures is the frequent ability to demonstrate at an earlier stage the location, and sometimes the character, of the lesion. Also, it provides an unexcelled means of studying disorders of the intracranial portion of the optic nerve. Impingements of the adjacent arteries on the nerve as it enters the foramen are well visualized, and it can be determined whether the displacement is caused by pressure from a tumor or is the result of arteriosclerosis. Moreover, unexplained primary optic atrophy caused by sclerosis of the arteries supplying the nerve can be detected in no other way short of surgical exploration.

Lack of time prevents more than a cursory discussion of the complications associated with angiography. These will be discussed in detail in the published paper. Needless to say, the injection of foreign material into the cerebral vessels cannot be treated lightly. Certain side-effects occur almost routinely, but serious complications

seldom follow, and death ensues only occasionally. Complications related to visual disturbance are rarely encountered. The visual loss is almost always transitory and confined to the side of the injection. So far, the literature, reveals two cases of permanent field defects and one of total visual loss. Any danger associated with angiography is compensated for by the valuable information obtained by its use when indicated.

In the angiographic study of intracranial lesions the ophthalmologist and the neurologist meet on common ground, and there should be close cooperation between them throughout the progress of the case.

DISCUSSION

DR. BRONSON SANDS RAY: This paper is both timely and provocative. Intracranial angiography, though now 20 years in its development, has only in the last few years come to be used widely. We not only are still in the process of improving techniques and contrast materials but are learning the possible diagnostic values, as we can do only through a large experience.

In the diagnosis of brain tumors, most neurosurgeons are employing the method principally as an adjunct. But they are still inclined to rely on pneumographic studies, against which is matched the efficiency of other diagnostic procedures, such as the electroencephalogram and radioactive isotope studies. The angiogram is usually performed first, and sometimes it is unnecessary to add the air study before proceeding with a craniotomy and surgical attack on the tumor. The hope of some that by angiography one could reliably identify a malignant and inoperable glioma has not materialized.

Angiography is of greatest value in identifying saccular aneurysms and arteriovenous anomalies. For these lesions the test is irreplaceable.

I have listened with a great deal of interest to Dr. Joy's description of the angiographic patterns seen with lesions about the sella turcica. He has emphasized the important points and brought out some of which I was not aware, or perhaps have not given enough attention to. His suggestion of more intensive use of angiography in identifying orbital lesions deserves consideration, though I have been disappointed in its usefulness in several cases of intraorbital tumor in which injection of both the internal and the external carotid system has been employed.

Dr. Joy's suggestion of utilizing the optic foramen roentgenographic projection to bring out abnormalities may be particularly useful. I have not utilized this method, and apparently few have.

I agree with Dr. Joy that from angiography there is much that can be learned about lesions, particularly neoplasms that involve the visual pathways, and I repeat that as an adjunct to diagnosis it is often valuable. But a group of ophthalmologists need not be reminded that the established examinations, if carefully and intelligently employed, are still our most reliable methods of diagnosis. I refer to funduscopic examination, acuity tests, perimetry, neurological examination, and roentgenography. It is rare that a surgical lesion or the need for an exploratory operation cannot be recognized by these established methods, and it would be sad indeed if a notion should grow that they could be replaced by angiography. I am sure Dr. Joy would equally discourage any such tendency.

It has already been pointed out that the angiogram cannot be relied upon to differentiate such lesions as pituitary adenomas and sellar meningiomas, which also often defy clinical differentiation before operation. Perhaps the greatest value of angiography for lesions about the sella is the identification of aneurysms, since these lesions must be dealt with in a special way, and it may be disastrous to come unwittingly on an aneurysm at operation when one expects a neoplasm.

While it is probably true that whatever risks attend angiography are acceptable in terms of its usefulness in selected cases, still one cannot completely ignore the existing risks. It is unfortunate that Dr. Joy did not take time to go into some of the complications of angiography, particularly as they would be of interest to ophthalmologists. A variety of visual complications, temporary or even permanent,

have occurred after angiography. Fortunately, they do not occur often. For this reason, angiography, at least in its present stage of development, can hardly be looked upon as a harmless laboratory procedure. It is not comparable to intravenous pyelography, or even to angiocardiography.

In our series of over 500 cerebral angiograms at the New York Hospital, two deaths have been directly attributed to the procedure, as well as an impressive number of major and minor complications, some ophthalmological; and we have not yet encountered some that have been reported by others. In patients who may already have a small margin of vision preserved, the possible complication of additional visual loss from angiography is not to be taken lightly. For these reasons, I do not believe that ophthalmologists should be led to believe that angiography need be included as a part of the examination of all patients.

But having voiced this cautious attitude, I hasten to add that I am actually enthusiastic about the place of angiography in the diagnosis of lesions of the visual pathways and wish again to commend Dr. Joy on his contribution. Neurosurgeons and ophthalmologists have long and profitably met at the crossroads of the chiasm and must continue to do so.

DR. HAROLD H. JOY, Syracuse, N. Y.: I wish to thank Dr. Ray for a most interesting discussion and to point out that I am not advocating that angiography take the place of a complete ophthalmologic examination; rather, I suggest it as a supplement when indicated. I firmly believe that it is a most important diagnostic procedure, which in many cases of unexplained visual defects will disclose the presence of an intracranial lesion in time to preserve sight, and sometimes life itself. One sees too many patients who have suffered serious visual loss unnecessarily because of misplaced reliance on the value of negative neurologic and routine roentgenographic findings. In such cases the investigation has not been complete, and, no matter how meticulous the ophthalmologic examination, the patient has been done a gross disservice. Since angiography will frequently disclose tumors in their incipiency, when removal is comparatively easy, as in the case of meningiomas, the procedure should not be unnecessarily delayed. I agree with Dr. Ray that angiography is by no means a minor procedure and that serious consideration must be given the complications which may occur. We have had one death in 500 angiographies. Falls and his group (Falls, H. F.; Bassett, R. C., and Lamberts, A. E.: A. M. A. ARCH. OPHTH. **45**:623, 1951) found ocular complications in 86.3 of 80 consecutive cases. These were mostly minor, consisting of petechiae and retinal hemorrhages. So far, we have observed petechiae in only two patients and have found no retinal hemorrhages. However, we have made a comparable statistical study of all fundi. This we are in the process of doing.

In closing, I wish to impress on Dr. Ray that I as an ophthalmologist do not presume to suggest to him or to any other neurosurgeon when an angiogram should be done. But I do think it important that ophthalmologists be much more aware of the availability of a procedure which in certain cases affords valuable assistance in the early diagnosis of intracranial lesions affecting vision.

News and Comment

EDITED BY DR. W. L. BENEDICT

GENERAL NEWS

University of Florida Midwinter Seminar in Ophthalmology and Otolaryngology.—The eighth annual University of Florida Midwinter Seminar in Ophthalmology and Otolaryngology will be held at the Sans Souci Hotel, in Miami Beach, the week of Jan. 18, 1954. The lectures on ophthalmology will be presented on Jan. 18, 19, and 20, and those on otolaryngology, on Jan. 21, 22, and 23. A midweek feature will be the midwinter convention of the Florida Society of Ophthalmology and Otolaryngology on Wednesday afternoon, Jan. 20, to which all registrants are invited. The registrants and their wives may also attend the informal banquet at 8 p. m. on Wednesday. The Seminar schedule permits ample time for recreation.

The Seminar lecturers on ophthalmology this year are Dr. W. B. Anderson, Durham, N. C.; Dr. W. P. Beetham, Boston; Dr. W. C. Owens, Baltimore, and Dr. A. B. Reese and Dr. M. C. Wheeler, both of New York. Those lecturing on otolaryngology are Dr. E. N. Broyles, Baltimore; Dr. H. P. House, Los Angeles; Dr. W. J. McNally, Montreal, Canada, and Dr. Dorothy Wolff and Dr. D. Woodman, New York.

Liga contra la Ceguera, Cuba.—The Liga contra la Ceguera of Cuba will open a new school of specialization in ophthalmology in Habana. The studies, with theoretical and practical training, will consist of two years, in addition to which a postgraduate course of one year will be given. Dr. Tomas R. Yanes is appointed head of the school. The first course will start in July, 1954, consisting of four semesters, up to a total of 800 hours. The tuition is $500, payable in two semesters, $250 each. The school has no dormitories. The first matriculation is restricted to 20 candidates, including Americans and Latin Americans, 35 years old and with practice for less than five years. Further information should be obtained from the secretary of the school, Dr. M. Farinas Pelletier, Liga contra la Ceguera, Apartado de Correos 4053, Habana, Cuba. Blanks for inscription should be requested before May 31, 1954. The Liga has its proper hospital. Near the hospital there are residential homes in which the students can have room and board for $50 a month.

Stanford University Postgraduate Conference in Ophthalmology.—Stanford University School of Medicine will present the annual postgraduate conference in ophthalmology from March 22 through March 26, 1954. Registration will be open to physicians who limit their practice to the treatment of diseases of the eye, or of the eye, ear, nose, and throat. In order to allow free discussion by members of the conference, registration will be limited to 30 physicians.

Instructors will be Dr. A. Edward Maumenee, Dr. Dohrmann K. Pischel, Dr. Jerome W. Bettman, Dr. Max Fine, Dr. Earle H. McBain, and Dr. Arthur J. Jampolsky.

Programs and further information may be obtained from the Office of the Dean, Stanford University School of Medicine, 2398 Sacramento St., San Francisco 15.

Thirteenth Clinical Meeting, Wilmer Residents Association.—The thirteenth clinical meeting of the Wilmer Residents Association will be held at the Wilmer Ophthalmological Institute of The Johns Hopkins Hospital on April 1, 2, and 3, 1954.

Mark J. Schoenberg Memorial Lecture.—Dr. Alan C. Woods, ophthalmologist in chief at The Johns Hopkins Hospital, Baltimore, will deliver the seventh annual Mark J. Schoenberg Memorial Lecture at the New York Academy of Medicine at 8 p. m., Monday, Dec. 7, 1953. His subject will be "The Diagnostic Problem of Uveitis."

The lecture is presented annually by the New York Society for Clinical Ophthalmology and the National Society for the Prevention of Blindness in memory of Mark J. Schoenberg, who died in 1945. Dr. Schoenberg was chairman for several years of the National Society's Committee on Glaucoma and was deeply interested in the subject of uveitis.

Call for Papers for the Joint Session of the Section on Ophthalmology of the American Medical Association and the Association for Research in Ophthalmology, San Francisco, June 21-25, 1954.—The 1954 meeting of the Section on Ophthalmology will be held in San Francisco, June 21 to 25, 1954. Again, the Section will meet simultaneously with the Association for research in Ophthalmology.

Anyone wishing to present a paper before the Section on Ophthalmology is urged to communicate with Dr. Harold G. Scheie, Secretary of the Section, 313 So. 17th St., Philadelphia 3, as soon as possible. A title and abstract must be in his hands by Jan. 1, 1954.

Anyone wishing to apply for space in the Scientific Exhibit of the American Medical Association should contact Dr. William F. Hughes Jr., 1853 W. Polk St., Chicago 12.

Anyone wishing to present a paper before the Association for Research in Ophthalmology should communicate with Dr. Lorand V. Johnson, secretary of the Association, 10515 Carnegie Ave., Cleveland 6, as soon as possible.

Members are reminded that their contributions to the Knapp Fund are now due and payable to Dr. Parker Heath, 243 Charles St., Boston. A $10.00 contribution entitles you to a volume of the 1953 *Transactions*. Contributions in excess of $10.00 are invited.

Research Fellowship in Ophthalmology, Indiana University Medical Center.—Information regarding a Research Fellowship in Ophthalmology at Indiana University Medical Center may be obtained by writing to Dr. T. F. Schlaegel Jr., 1100 W. Michigan St., Indianapolis 7. It is not necessary to have had training in ophthalmology to be accepted for this position. For those who have not had a graduate course in ophthalmology, the fellowship will provide some training prior to a residency. Fellows assist in the eye clinic and at eye surgery and attend the formal classes for eye residents. The stipend is $1,800 per year plus room and laundry.

PERSONAL NEWS

Dr. Arnold H. Knapp Honored.—Dr. Arnold H. Knapp, professor emeritus of ophthalmology at Columbia University and consultant at the Presbyterian Hospital, is one of 25 persons who will receive Distinguished Service Awards in connection with the 25th anniversary of the Columbia-Presbyterian Medical Center on Oct. 12 and 13. The awards, first of the kind ever made by the institution, will commemorate the contributions by Dr. Knapp and his colleagues to the growth and development of the Medical Center.

Dr. Knapp, who was graduated from Columbia University College of Physicians and Surgeons in 1892, has a service record of 58 years in medical science. In 1932, Dr. Knapp received an honorary Doctor of Science degree from Columbia.

A leader in the field of ophthalmology, Dr. Knapp served as executive director of the Herman Knapp Memorial Eye Hospital, founded by his father, until its merger with the Institute of Ophthalmology of the Presbyterian Hospital, in 1940. He created the Knapp Memorial Foundation for the advancement of postgraduate

teaching, study, and research in ophthalmology. Chief editor of the ARCHIVES OF OPHTHALMOLOGY for 40 years, Dr. Knapp has written extensively in his clinical field. A past president of the American Ophthalmological Society, he has also been an honorary member of foreign societies. In 1941 the National Society for the Prevention of Blindness presented him with the Leslie Dana Gold Medal.

Dr. Grayson Kirk, president of Columbia University, and Charles P. Cooper, president of Presbyterian Hospital, will make the award presentations at an academic convocation on Oct. 13. This event climaxes a two-day scientific and social program to mark the 25th anniversary of the dedication of the Medical Center.

SOCIETY NEWS

New York Society for Clinical Ophthalmology.—The guest speaker at the Nov. 2, 1953, meeting of the New York Society for Clinical Ophthalmology will be Norman Ashton, Director of Pathology of the Institute of Ophthalmology, University of London. His paper is entitled "Some Anatomical Factors in the Genesis of Ocular Disease."

St. Louis Ophthalmological Society.—The St. Louis Ophthalmological Society will hold meetings on the following Thursdays of this fiscal year: Oct. 22 and Dec. 3, in 1953, and Jan. 28, Feb. 25, March 25, and April 22, in 1954, at the Park Plaza Hotel, 220 N. Kingshighway, St. Louis.

Ophthalmological Society of the United Kingdom.—The Annual Congress will be held in the department of chemistry, University of Durham, Newcastle-on-Tyne, on April 22 through 24, 1954.

The discussion will be on "Inflammatory Vascular Diseases Affecting the Eyes." This will be opened by Mr. R. C. Davenport, Dr. S. P. Meadows, and Prof. J. B. Duguid. Members who wish to take part in the subsequent discussion are advised to intimate their intention before the opening of the Congress. It is emphasized that no member may speak for more than 10 minutes.

There will also be three short symposia on the following subjects: "Cyclodiathermy," "Changes in the Incidence of the Eye Affections of Coal Miners in the Past 25 Years," and "Gonioscopy."

Members wishing to read a short paper are asked to send the title, together with an abstract, to Mr. Arthur Lister, 45 Lincoln's Inn Fields, London, W.C.2, not later than Dec. 31, 1953. Those wishing to show films should also communicate with Mr. Lister by the same date.

The annual dinner will be held at the Royal Station Hotel on Thursday, April 22. Members may bring guests.

A civic reception will be held at the Laing Art Gallery on Friday, April 23, at 9 p. m.

A trade exhibition will also be arranged during the meeting.

The following hotels are within easy reach: Royal Station, Royal Turk's Head, Grand and County.

Books

Physiology of the Eye. Volume 2: Vision. By Arthur Linksz. Price, $19. Pp. 869 + VII, with 248 figures. Grune & Stratton, Inc., 381 4th Ave., New York, 1952.

Until recently it has been virtually impossible to find a text in English devoted to the physiology of the eye, more especially to the physiology of vision. The appearance, during the past few years, of a number of books on these subjects is a welcome sign of the increasing interest in the physiology of vision.

Among these books the volume written by Linksz occupies a special place. It is an important book. More than that, it is a beautiful book. The author has an immense learning in the fields of which he treats, and in biological sciences in general. He is a man of vast culture and, what is more, a man with deep reverence for the things of the spirit. And he has the unusual courage not to hide these in writing a scientific treatise.

Some readers may not appreciate what Linksz calls his humanistic approach. The full significance of many of the things he touches upon will elude those who do not bring to the book a humanistic background comparable to that of the author's. Many will be disturbed by the frequent intrusion of philosophical and cultural interludes. Those seeking factual information may be discouraged—and not quite without reason—by the theoretical nature of the text. It is typical of Linksz's procedure to present a hypothesis, to make what he calls the necessary assumptions, and to look only secondarily for factual confirmation. The author has, one feels, a synthetic rather than an analytical mind; he appears to be a thinker rather than a doer. One is tempted to call the book a "theoretical biology of vision," not a "physiology of vision," despite the author's emphasis on the physiologic point of view.

Even those in whom Linksz's treatment of the material strikes a responsive chord will find the book often difficult reading, not because of conceptual difficulties, but because of the way in which it is written. The book is conceived as a textbook. It takes the form of lectures to beginners. This makes for a lively, occasionally anecdotal, style in the first person singular and second person plural. In itself, this is both pleasant and refreshing. But in his attempt to be didactic, to drive important points home, the book also becomes extremely verbose. Relatively simple thoughts are needlessly elaborated; endless repetitions, frequent interludes disturb the continuity. It is difficult for this reviewer to say whether such a treatment of the material is helpful to the tyro, but it would seem doubtful. To those who have a certain mastery of the subject the method of presentation makes it undoubtedly more difficult to get at the many new and interesting concepts with which this book abounds.

This is regrettable, for many of these concepts are important and original; others give an original twist to older ways of thinking. If one cannot agree with all of them, they always are stimulating and provocative.

It is difficult to provide a summary of these concepts.—To discuss them critically is impossible. One can only attempt to give an idea of the rich harvest which the attentive reader of the book collects.

The first part, entitled "Analysis of Sensation," sets the stage for everything that is to come. The fundamental concepts of sensory physiology are discussed; the meaning of Johannes Müller's concept of specific nerve energies and of the adequate stimulus is thoroughly presented. In the light of this, the lack of parallelism between physical stimulus and physiologic event, on the one hand, and the parallelism or isomorphism of physiologic and phenomenal events, on the other, are discussed in detail. The theory of color vision makes up the bulk of the first part. The author presents a modern elaboration of Hering's theory of color vision, of which he is a convinced adherent. This presentation is well worth careful reading.

In the second part, "Pattern and Detail Vision," the discussion of some fundamental problems of sensory physiology, such as sensation versus perception, is continued. Color constancy, the contrast phenomena, after-images, flicker fusion, visual acuity, differential sensitivity, and many similar phenomena are taken up.

The third major section of the book (and it is major, coming to 385 pages) deals with the perception of spatial relationships, a subject which has obviously engaged the author's attention for many years. The teachings of the Hering-Hillebrand-Tschermak school, on which this section is based, undergo a thorough critical review.

"Space" is not an aprioristic category of the mind in the Kantian sense. Neither is the perception of spatial relationships a modality of sensation. It is a quality of the phenomenal world. Spatial inhomogeneities in the physical world find their direct replica in the visual organ. By this is meant that the neuroanatomic relationships in the visual organ provide for the spatial order of physiologic events, to which corresponds the phenomenal spatial order. The complete crossing of the optic nerves in animals with laterally placed, more or less immobile eyes, with their double fovea, their "oriental" point, and point-like horopter, results in panoramic vision. In the primates, with the partial crossing of the optic nerves a new neuroanatomic relationship is created. Binocular vision, fusion, comes about through actual merging of physiologic events in one cortical locus. For the fusion of excitations coming from corresponding retinal elements this locus is Gennari's stripe, with its connections in the horizontal extension. The fusion of excitations from stimulation of noncorresponding elements occurs in the granular layers in front or behind Gennari's stripe. This is stereopsis. If fusion cannot occur because there is no cortical locus where the gradients from the two eyes can meet, diplopia is the result. Visual directions are not retinal, but retinocortical; the center of the visual directions is the egocenter; differentiation of relative and egocentric localization is artificial and unnecessary. Retinal correspondence is a strictly neuroanatomic concept and absolutely rigid. In such a system there is no room for "abnormal" correspondence. The vision of the squinter is essentially an alternate monocular replacement, reverting to something like panoramic vision. The phenomena observed in patients and designated as "anomalous correspondence" are either the confused and confusing reports of patients with amblyopia or the correct interpretation, on the part of the patient, of monocular visual directions.

Noteworthy features of this section are the considerable space given to the geometric analysis of the horopter, to Luneburg's mathematical analysis of phenomenal space, and to the role of nonstereoscopic clues in the total act of vision.

The last, and fourth, part of the book is of special interest to the ophthalmologist. It is devoted to "Vision and the Oculo-Rotary Reflexes."

Vitalistic concepts, purpose, plan, etc., are not permissible in biology. Ocular movements are not directed by higher centers: voluntary centers, centers for convergence, elevation, etc. The term center should not be used, except to denote areas in the central nervous system where afferent impulses are relayed into efferent

pathways. All eye movements are reflex in nature. The most important ones are optically elicited. In animals with total crossing of the optic nerves each visual cortex contains spatially separated centers for levoversion and dextroversion, sending crossed impulses to the dextrorotators and levorotators of the eyes. In animals with partial crossing there are in the left hemisphere (presumably in the peristriate and parastriate areas) centers for dextrorotation and for elevation and depression in the right field of fixation, and in the right hemisphere there are centers for levorotation and for elevation and depression in the left field of fixation. This is the neuroanatomic basis for motor correspondence. Through bifurcation of the optic nerve fibers the retinal foveas are bilaterally represented in the visual cortex. The great bulk of the cortical fovea explains the prevalence of the opticomotor effectivity of the foveal area and ensures fixation and refixation. From the cortical fovea equal impulses are sent to the oculorotary centers which cancel each other. This is fixation. Ocular motility thus serves, in the first place, to keep the eyes immobile. Lateral displacement of the images on the retinas disturbs this equilibrium and leads to pursuit, or refixation, movements. Heteronymous (temporal) displacement of images on the retinas in the two eyes should lead to adduction of each eye, but this movement ("fusional" convergence) could not be effected without a prevalence of innervations to the medial rectus muscles. This prevalence comes about through an amplification of impulses in Perlia's nucleus. Convergence is initiated by nonoptically elicited impulses via accommodation or from the pre-Rolandic area ("voluntary" convergence). The facilitation due to the "Perlia mechanism" explains the esophoria caused by anoxia or alcoholic intoxication, as well as the etiology of convergent strabismus. There is either an excess of the integrative overflow reflex of accommodation (accommodative esotropia) or a psychoneurotic overflow reflex (non-accommodative esotropia).

Bilateral nasal displacement of images on the retinas should also lead to convergence, according to the neuroanatomic hypothesis outlined, but this is prevented by inhibition. Inhibition means control by sensory feed-back—the organism controls its activities by their outcome. Thus, binasal displacement leads to deconvergence. There is no active divergence; there is no divergence center. There are no fusional movements, in the sense that there are no movements initiated by compulsion or desire for fusion. Vergences are the result of purely physiologic reflex processes.

Nonoptically elicited ocular movements of profixation (versions) arise from excitations in the pre-Rolandic area. These are not "voluntary." Voluntary and reflex are not antonyms. Reflexes entailing processes in cortical areas generally have the phenomenal attribute of being "willed." Reflexes restricted to lower areas of the central nervous system do not have this attribute; they appear to be "unwilled." But the "will" does not initiate these movements. Excitations of the postcentral area result in coarse reflex movements, for instance, cycloversions, due to proprioceptive stimulations. They contribute to keeping the eyes properly oriented, as do the eye movements elicited by labyrinthine reflexes.

In addition to these matters, optokinetic, otogenous, and spontaneous nystagmus, perception of motion, and torsion movements are all exhaustively discussed; a theory of double innervation of the extraocular muscles is given, and a master plan of the greater oculomotor nucleus is drawn in great detail.

This short outline of the main ideas of the book must suffice to indicate that everyone will be greatly enriched who has the patience to study it. The reader will sometimes be exasperated, often exhilarated. He will always be delighted with the singlemindedness with which all phenomena of vision are brought within the orbit of physiology.

Headaches: Their Nature and Treatment. By Stewart G. Wolf and Harold G. Wolf. Price, $2.50. Pp. 177. Little, Brown & Company, 34 Beacon St., Boston 6, 1953.

Addressed to the general public, this book is intended to give a comprehensive review of the nature and treatment of one of civilized man's commonest complaints. The mechanism which produces headache is outlined, and headaches from specific causes, such as brain tumor, high blood pressure, sinus disease, ocular pathology, and migraine, are discussed. This volume has no value to the ophthalmologist except in recommending it to patients who have an interest in a better understanding of their condition, especially those suffering from migraine. The authors are well known for their numerous researches in pain, especially headaches, and the book admirably fulfills its purpose.

Le gliome de la retine et les pseudogliomes. By Marc-Arden and Dollfus Bertranne Auvert. Price not given. Pp. 525, with 101 figures. Masson le Cie, 120 Boulevard Saint-Germain, Paris, 1953.

Société française d'ophthalmologie continues to publish monographs which are of great value to ophthalmologists all over the world. The last of these is a monograph on retinoblastomas. Unfortunately, the authors continue to use the term "glioma" rather than the one proposed in 1926 by Verhoeff.

This volume is a documentation of the world literature and contains a practically complete bibliography. To those who read French the book will be very welcome.

Visibility: A Bibliography. By M. Leikind and J. Weiner; edited by J. R. Gibson. Price, 65 cents. Library of Congress, Washington, D. C.

This bibliographical list of 2,008 references was prepared at the request of the Armed Forces NRC Vision Committee in the office of Naval Research as a task under contract. It is intended to provide reference information and background material for the many research and development projects in the field division, being sponsored by the Vision Committee. It will also be useful for all researchers in this field. It is comparable in many respects to the bibliography published a few years ago by Fulton in the same field. The bibliography is divided into the following categories: (1) Visual Detection Factors in the Laboratory; (2) Physical Variables in the Field; (3) Field Visibility Computations, Measurements and Observations, and (4) Engineering Applications of Visibility Data.

There is an author index at the end.

Fundus Oculi—Patologia clinica vasculo-retiniana. By Hector M. Nano. Pp. 552. Printed by Talleres Graficos "Optimus," Buenos Aires, Argentina, 1953.

This well-documented and comprehensive volume is divided into 18 chapters under seven sections (Diseases of the Nerve Head, Circulatory Disturbances of the Retina, Vascular States of the Fundus Especially Related to Arterial Hypertension and Arteriosclerosis, Retinopathy of Pregnancy, Diabetic Retinopathy, Retinopathies and Papillopathies of Diseases of the Blood, and Circulatory Disturbances of the Choroid). Of the 241 illustrations, 75 are in color, 66 having been prepared from drawings by the author. A list of the colored illustrations would be useful. At the end of each section is a bibliography, which is divided into national and foreign references. Under the various chapters, the author includes excellent classification tables.

The papillopathies are logically grouped into the edemas and the atrophies. After reviewing a number of classifications for hypertensive and arteriosclerotic retinopathy, the author submits the following seven clinical subdivisions: (1) vascular syndrome of hypertension, (2) sclerotic-hypertensive vascular syndrome with normal caliber of arterioles, (3) sclerotic-hypertensive vascular syndrome with narrowed arterioles, (4) sclerotic-hypertensive retinopathy, (5) renal retinopathy with mild or absent vascular changes, (6) renal retinopathy with evident vascular alterations, and (7) retinopathy of malignant hypertension.

There is some irregularity in the pagination in the beginning of the book and in the case of several color plates. A number of typographical errors and misspellings were noted, especially in the bibliographies.

This volume represents an immense amount of work. The reader will benefit from the author's reviews of the literature and from his clinical portrayal of the subjects dealt with in this book.

Alternerende hyperphorie (Alternating Typerphoria). By R. A. Crone. Price not given. Pp. 178, with 17 figures. C. V. Swets & Zeitlinger, Amsterdam, The Netherlands, 1952.

This monograph is written in Dutch, and therefore will be read by few American ophthalmologists. The first two chapters cover the basic physiology of ocular movements and optomotor reflexes. Special attention is given to what the author refers to as "Zeeman's theory," which seems to be identical with that of Chavasse, according to which the optomotor reflexes have developed as conditioned reflexes on the basis of the primitive vestibular and proprioceptive mechanisms. The rest of the book concerns the investigation of 113 patients with alternating hyperphoria. The author found that in these cases a hyperphoria could almost always be elicited in lateral versions when the eyes were uncovered. Usually alternating hyperphoria was accompanied by tonic rotatory deviations, in which the covered eye undergoes exorotation and the uncovered one endorotation. Rotatory nystagmus was frequently found, which changed to a horizontal jerking nystagmus when one eye was covered, the fast component of which was directed toward the side of the uncovered eye (latent nystagmus). The author defines the complex of manifestations seen in alternating hyperphoria as follows: (1) alternating hyperphoria, (2) strabismus, (3) hyperphoria in lateral directions of gaze, (4) rotatory nystagmus, (5) latent nystagmus, and (6) homonymous torsion of the eyes in the direction of the covered eye.

It is believed that a tendency to alternating hyperphoria is present in latent form in many persons, as shown by the frequency with which alternating hyperphoria becomes manifest when binocular vision has been interrupted for a considerable time. This monograph seems to be a valuable contribution, and it is regrettable that it was not published in a more universal language.

De optische localisatie onder invloed van optische en houdingsfactoren (Optical Localization Under the Influence of Optical and Postural Factors). By R. P. Mesker, Amsterdam, Swetx & Zeitlinger, 1953.

During the last war much research was done on determining those factors which influence our ability to judge vertically and our own bodily orientation in space. The importance of these factors to the airplane pilot is obvious. These, of course, involve the physiology of the vestibular and visual systems, particularly as they are affected by head and body orientations and by psychologic influences, such as optokineses.

This monograph, in Dutch, with English, German and French summaries, deals with specific researches in this field: a study of the apparent vertical in the fronto-parallel plane (that is, so far as a tilting to the right or left is concerned—but not stereoscopic vertical), and the apparent median plane of the head when subjected to (1) surrounds consisting of grid pattern of lines that can also be tilted and (2) tilting of the head to one side. Mesker cites and discusses the researches of the large number of earlier workers before proceeding to his own results.

He found that inclined contours cause a cyclotorsion of the eyes, a tilt of the apparent vertical, and an incline of the apparent median plane toward the direction of inclination of the contours (attraction) up to 45 degrees, when these go in the opposite direction (repulsion). The cyclotorsion of the eyes is much smaller than the inclination of the apparent vertical and the median plane of the head. With an inclination of the head there is, with the well-known countercyclotorsion of the eyes, a rotation of the apparent median plane that approaches the amount of that cyclotorsion. However, the apparent vertical is only slightly inclined in that direction, and therefore must be considered a large rotation in the opposite direction referred to the principal sections of the retinas.

These different relationships of the torsion of the eyes and the inclinations of the apparent vertical and the median plane of the head are accounted for by the author by an innervation-tonus theory, which involves the concept of a physiologic position of rest (he admits that no such position of rest exists for movements of the eyes in the horizontal) and the innervation stimulus to the extrinsic muscles from objects observed (optokinetic influences). The apparent median plane under postural influences is identical with the original retinal vertical meridian. The direction of the subjective vertical indicates the direction of the rest or equilibrium position of the head. The reflex effect of the oblique contours on the innervation tonus of the ocular and body muscles Mesker regards as originally a conditioned reflex in the sense proposed by Pávlov. This innervation-tonus theory is discussed at considerable length in the monograph, and the above summary is inadequate to do justice to Mesker's analysis.

NOW– MORE ACCURATE VISUAL DIAGNOSIS IN THE EYE, EAR, NOSE AND THROAT

WITH THE NEW, IMPROVED

A.C.M.I. DIAGNOSTIC SETS

American Cystoscope Makers offers the medical profession the finest line of Diagnostic Sets in its entire history. These new sets incorporate the outstandingly important feature—exclusive with the ACMI ophthalmoscope—of a coated lens system, greatly increasing the amount of light transmitted, improving definition and clarity of the image, and eliminating halo, flare and ghost images.

STANDARD SET comprises ophthalmoscope head (with built-in color filter and aperture changer), otoscope head with 3 specula, medium battery handle and one spare lamp, in plush-lined case, with space for additional specula and tongue depressor.

COMPACT SET, for the practicing physician, includes ophthalmoscope head (with built-in color filter and aperture changer), otoscope head, 5 ear and 1 nasal specula, small battery handle and extra lamp. Additional space for tongue depressor and more specula.

LARGE SET contains otoscope head, 5 ear and 1 nasal specula, ophthalmoscope head (with built-in color filter and aperture changer), large battery handle, 1 extra lamp, with provision in case for tongue depressor head, additional specula and lamp replacement.

PROFESSIONAL SET. This, the most complete Wappler set, incorporates an otoscope head with 5 ear and 1 nasal specula, tongue depressor head, ophthalmoscope head (with built-in color filter and aperture changer), large battery handle, extra lamp, and rubber bulb for insufflation.

Standard Set, Catalog No. 1106

Compact Set, Catalog No. 1107

Large Set, Catalog No. 1109

Professional Set, Catalog No. 1111

AMERICAN CYSTOSCOPE MAKERS, INC.

Frederick J. Wallace, President

1241 LAFAYETTE AVENUE • NEW YORK 59, N. Y.

Spectel
TELESCOPIC SPECTACLES

1.7x
(with Coated Lens)

WHAT THEY ARE. A general discussion of the design, construction and uses of the improved Spectels. An outline of their development. Comparisons of the two magnifications and descriptions of the various trial sets. Bulletin 302.

HOW THEY ARE PRESCRIBED. Twelve pages of factual information on the application of telescopic spectacles. Case histories. Bulletin 304.

TRIAL PROCEDURE. A concise, step-by-step outline of the trial procedure which has been found effective. Bulletin 303.

TRIAL SETS. Complete descriptions and illustrations of the four different trial sets available. Form 85.

PRICES of Spectel telescopic spectacles, frames, trial sets and accessories are given in Form 7146-A.

This literature is available from your supply house or from

K O C

KOLLMORGEN Optical CORPORATION

Plant: Northampton, Massachusetts
New York Office: 30 CHURCH ST., NEW YORK 7, N. Y.

Distributed in Canada by Imperial Optical Company

Do you dispense glasses?

We are one of the oldest, and most reputable wholesale opticians in the east, serving the discriminate ophthalmologist.

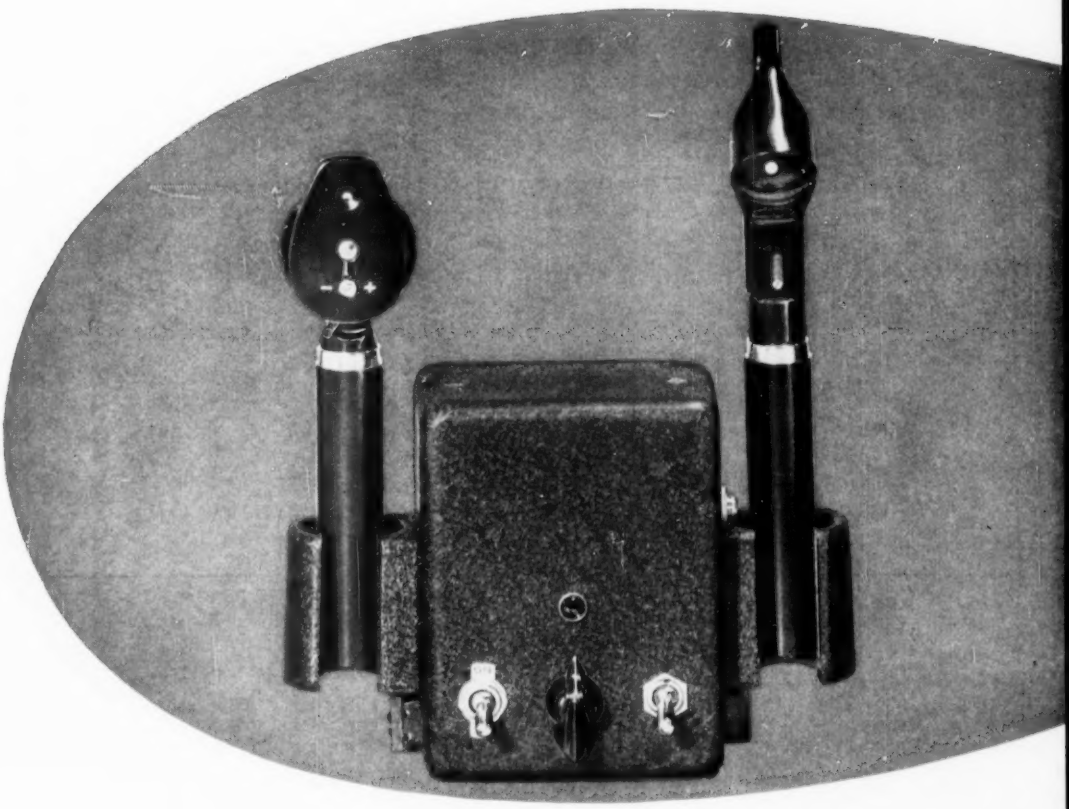
An inquiry from you will bring a representative at your convenience to outline our superior service plan.

MAX ZADEK, INC.

established 1904

115 Fulton Street — New York 38, N.Y.

A unique new transformer— the Jenkel-Davidson *TRANS-PORT*



$40.00
without instruments

THIS convenient, adjustable transformer for use in your office, has outlets for two diagnostic instruments. These outlets are controlled independently, with resistance variable from 0 to 6 volts. Handy indicator light provides constant reminder.

The Jenkel-Davidson Trans-Port is excellently designed and is made from the finest quality materials so you can use it for years.

When ordering, please specify the diameter of your instrument handles and the lamp voltage.

Jenkel-Davidson
OPTICAL COMPANY

366 POST STREET • SAN FRANCISCO, CALIFORNIA

Pilocarpine and other miotic solutions for glaucoma therapy

- sterile
- buffered for maximum stability
- quality-controlled
- preserved against contamination
- isoosmotic where possible
- of low surface tension
- ready-to-dispense

Now Available

Pilocarpine HCl. ½%, 1%, 2%, 4% (in 15 cc. sterile, sealed dropper bottles)

Eserine Salicylate ⅛%, ¼%, ½% (in 7.5 cc. sterile, sealed dropper bottles)

Pilocarpine HCl. 2% plus Eserine Salicylate ¼% (in 7.5 cc. sterile, sealed dropper bottles)

Pilocarpine HCl. 2% plus Eserine Salicylate ½% (in 7.5 cc. sterile, sealed dropper bottles)

Note: ISO-SOL Eserine Salicylate solutions will not discolor.

Write for a descriptive list of all ISO-SOL products.

THE ISO-SOL® CO., INC.

130 Flatbush Avenue, Brooklyn 17, New York

Pioneer specialists in sterile ophthalmic pharmaceuticals

In Canada: Ranar Co., 1245 St. Catherine St. W., Montreal, Canada

A New Service

cosmetic contact lenses

Patients with scarred and disfigured eyes can be fitted with clear contact lenses. Then, these same lenses are used in the making of the cosmetic contact lens.

In cases of strabismus with the scarred or distorted eye, the iris of the contact lens can be placed in such a position that it will look as straight as the other eye. The direction or degree of the tropia will not affect the fitting of the cosmetic contact lens.

If there is distortion or discoloration of the corneal or scleral section of the eye, then the cosmetic contact lens is made with a clear pupil so that vision is not affected.

Cosmetic contact lens fitting will add to your service to the patient. Write to us for instructional material on the fitting of the cosmetic contact lenses.

Serving the Profession Since 1851

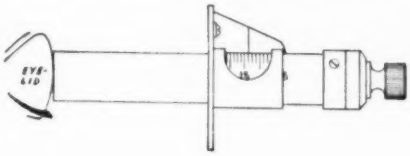
Mager and Gougelman, inc.

30 NORTH MICHIGAN AVENUE • CHICAGO 2, ILLINOIS

DETROIT • CLEVELAND • KANSAS CITY • MINNEAPOLIS • NEW ORLEANS • ST. LOUIS
NEW YORK • BOSTON • BUFFALO • PHILADELPHIA • PITTSBURGH • WASHINGTON

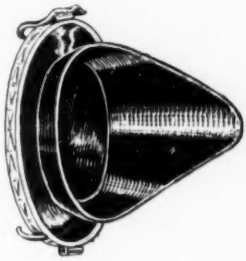
NEW—

For Green's Refractor
The Phoro-Lenscorometer



For use with *Green's Refractor* to measure vertex distance, just clear instrument of lenses, place Phoro-Lenscorometer through opening, making contact with patient's closed lid—and read *direct*. No computing necessary.

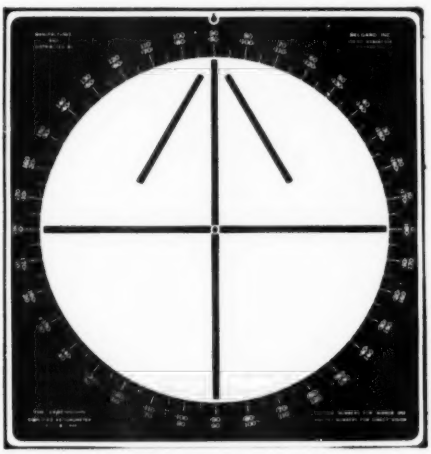
Each $12.75



BEL-O-CLUDERS

Easily and securely attached to any style frame. Affords complete occlusion. Sizes 34 through 46 eye. As single eye fit-over can be used on front or back of lens.

Each $1.50



(Actual size 13½" x 14")

SIMPLIFIED ASTIGMOMETER

(Lebensohn)

PLASTIC

WASHABLE

"NO COMPUTATION REQUIRED"

CAN BE USED AT 10 OR 20 FEET

Send for Literature

EACH $9.75

OPHTHALMIC OPTICIANS

WHOLESALE & SERVICE

Austin Belgard INC.

(Formerly Belgard, Inc.)

DISPENSING SERVICE
109 N. Wabash, at Washington
9th Floor STate 2-5362
CHICAGO, ILL.

Medical Center Office:
1920 W. Harrison St., at Ogden
CHICAGO, ILL.

THE "LACRILENS" ® IS A SAFE LENS

The Test Of Time Proves That The "LACRILENS"® Contact Lens Can Be Worn For Long Periods Of Time In Aphakia And In All Sports, Including Swimming.

WRITE FOR BROCHURE

Obrig Laboratories Inc.

49 EAST 51st STREET • NEW YORK, 22, N. Y.

Manufacturers of all types of Contact Lenses

BRANCHES IN

PHILADELPHIA MONTREAL JOHANNESBURG

Obrig ®

THE BRAWNER G-L

A Modern Inclusion Implant

Designed to:

- Simplify the operation — Eliminate muscle isolation
- Furnish satisfactory prosthesis motility
- Have no exposed face — Full inclusion
- Minimize the possibility of extrusion
- Reduce patient's post-operative discomfort
- Shorten post-operative hospital time

Full information, including description, prices and operative technique, as suggested by Dr. Brawner, will be sent on request.

Galeski Laboratory Inc.

737 East Main Street

Richmond 19, Virginia

Here is The Eye Magnet you have been Waiting for

The Magnet that has THE BIGGEST "PULL"
The Magnet that allows you to SEE WHAT IS HAPPENING.

The Philps Giant Magnet

MADE BY
HAMBLINS of
ENGLAND

Some Other Points

- ★ Applicators readily removed for sterilizing.
- ★ Four different shaped applicators provided.
- ★ Magnet counter-balanced for feather touch.
- ★ Locks on all movements
- ★ High and low powers from same footswitch.

THEODORE HAMBLIN LTD
DISPENSING OPTICIANS
15 WIGMORE STREET
LONDON W.1.

Agents:
The House of Vision, Chicago.
Anton Heilman, New York.
Parsons Optical Laboratories, San Francisco.

AND NOW *A New Grip on Problems of Industrial Medicine*

THROUGH A Journal Designed For Your Interests

A. M. A. Archives of INDUSTRIAL HYGIENE and OCCUPATIONAL MEDICINE

Edited by men of outstanding reputation in the fields of industrial health and preventive industrial hygiene: Prof. Philip Drinker, Boston, Chief Editor; Robert Kehoe, M.D., Cincinnati; James Sterner, M.D., Rochester, N. Y.; Frank Patty, Detroit, Mich.; Theodore Hatch, Pittsburgh; Frank Princi, M.D., Cincinnati; Fenn E. Poole, M.D., Glendale, Calif.; William A. Sawyer, Rochester, N. Y.

Covering the research and field aspects of industrial hygiene and the clinical and medical aspects of occupational industrial health programs.

Merging the best features of *Occupational Medicine* and *The Journal of Industrial Hygiene and Toxicology*.

Integrated closely with the activities of the Council of Industrial Health of the A. M. A. and the American Industrial Hygiene Association.

A Better and More Useful Journal of Industrial Medicine!

Such is the result which the Editorial Board of A. M. A. Archives of INDUSTRIAL HYGIENE and OCCUPATIONAL MEDICINE has achieved by combining parallel publications.

To the thousands of physicians who are directly or indirectly concerned today with medicine in industry, the new journal will bring reports of the continuing and important developments in the field, with original articles covering problems and day to day experiences of physicians in industry; an excellent abstracting service similar to that carried in the *Journal of Industrial Hygiene and Toxicology;* additional foreign journal abstracting; reviews.

Whether servicing industrial firms, attending employees, applying to general practice some of the findings of industrial medicine, or merely *watching* this expanding field, you will want to receive this vital new periodical.

AMERICAN MEDICAL ASSOCIATION
535 N. Dearborn Street, Chicago 10

Enter my subscription to A. M. A. Archives of INDUSTRIAL HYGIENE and OCCUPATIONAL MEDICINE to start *with the next issue*. Per year, $8.00 in U. S. (Canadian, $8.40; Foreign, $9.00).

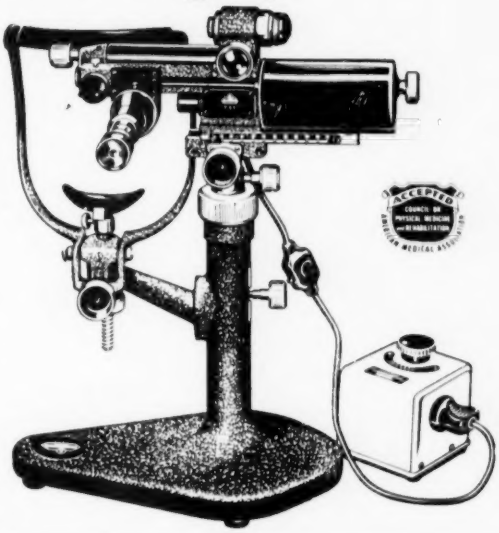
I enclose check..... Please bill me.....

Name.....

Address.....

Eliminates Refraction Drudgery!

THE NEW Rodenstock EYE-REFRACTOMETER



Excellent for the objective determination of refractions of the human eye, the Rodenstock eye-refractometer permits instantaneous readings of spherical and cylindrical refractions including inclination of the axis.

It enables you to diagnose objectively problem cases like children, illiterates and cases of pin hole pupils, as size of pupil has no effect on efficiency. Eliminates time consuming basic diagnosis so tiring to the patient. Particularly helpful in difficult cases of strong astigmatism, extremely weak vision, sensitive or nervous patients. This instrument tends to stimulate the patient's confidence in the doctor as well as self-confidence of the patient.

Range from plus 20. O D to minus 20. O D

This is truly an instrument of the future . . . available to you today!

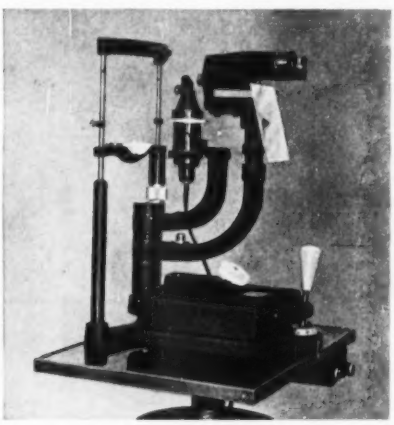
Ask a doctor who owns a Rodenstock!

The KRAHN Slit Lamp (HSE)

GIVES BRILLIANT ILLUMINATION . . .

Rapid, accurate examinations

- One-hand control lever (joy-stick) for all direction positioning
- Combined adjustability for Slit Lamp and Microscope with constant focus
- Same center level for slit and microscope of every axial rotation
- Hruby lens
- Brilliant illumination
- Sharply defined vertical and horizontal slit
- Interchangeable to Binocular Ophthalmoscope



The Slit Lamp gives a sharp-edged limited slit image and its light intensity is outstanding. The width of the slit is variable, may be narrowed down to the pin-point, completely closed or developed into a horizontal slit.

Fitted on instrument plate with glass top 12" x 16"

Ask a doctor who owns a KRAHN!

Rodenstock VERTEX REFRACTIONOMETER

- Range from plus 25. O D to minus 25. O D
- Fast, accurate, advanced optics with sensitive test-mark.
- Read power, axis, prism, prism base at a glance in the field of view ocular, simultaneously focusing test-mark.
- Marking device marks the cylinder axis according to RX.
- Dustproof construction in attractive housing of streamlined design.
- For accuracy, efficiency, speed and precision workmanship.

Unexcelled for measuring all types of lenses.

SHOWROOMS IN CHICAGO and LOS ANGELES

ANTON HEILMAN AO-1253

75 Madison Avenue, New York 16, N. Y.

Send catalog on

- ☐ Rodenstock Eye-Refractometer
- ☐ Rodenstock Vertex Refractionometer
- ☐ Krahn Slit Lamp Binocular Microscope (HSE)
- ☐ Krahn Binocular Ophthalmoscope (OFE)
- ☐ Krahn Ophthalmometer (BE)
- ☐ Krahn Prism Exophthalmometer (C)

Name .....

Address .....

City ..... State .....

Castroviejo

SPECIAL EYE SCISSORS

The Correct Patterns Beautifully Made in the Finest Stainless Steel

OP-5590 Castroviejo Corneal Scissors. Angular blades have dulled points to prevent injury to iris and lens in keratoplasty. Each, *$19.50.*

OP-5600 Castroviejo Corneal Scissors. Curved blades, also with dulled points. Each, *$20.50.*

OP-5605 Castroviejo Synechia Scissors. Properly curved blades. Each, *$21.00.*

ORDER DIRECT FROM

Instrument Makers To The Profession Since 1895

V. Mueller & Co. 330 SOUTH HONORE STREET CHICAGO 12, ILLINOIS

Your "experience exchange" in the field of Skin Diseases and Syphilis—A valuable guide in your Practice—

A. M. A. Archives of DERMATOLOGY and SYPHILOLOGY

SIGNIFICANT DEVELOPMENTS reported monthly to the specialist and the physician in general practice. From hospitals, clinics and government treatment centers here and abroad, A. M. A. Archives of DERMATOLOGY and SYPHILOLOGY gathers news of current trends in treatment and diagnosis, group case studies, clinical notes and comments on cutaneous conditions and syphilis.

Well illustrated.

Ably edited.

AMERICAN MEDICAL ASSOCIATION

535 N. Dearborn St., Chicago 10, Illinois

Please Begin My Subscription to A. M. A. Archives of DERMATOLOGY and SYPHILOLOGY with the Next Issue.

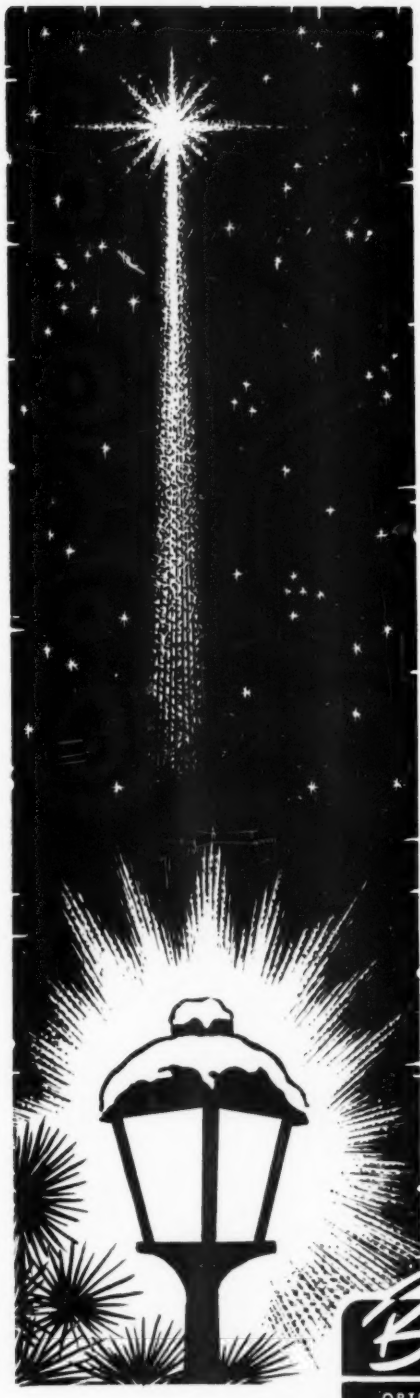
.....M.D.

.....STREET

.....CITY AND STATE

$12.00 YEARLY

$13.50 FOREIGN $12.40 CANADIAN



OUR FORTIETH

Merry Christmas

At this season of good will, we wish to express our appreciation to the Ophthalmic Profession for these four decades of friendly association. And we look forward to the opportunity of serving you in the New Year that lies ahead.

COMPLETE OPHTHALMIC SERVICE FOR THE PROFESSION

Benson
OPTICAL COMPANY

Executive Offices – Minneapolis, Minn.

Since 1913

LABORATORIES IN LEADING UPPER MIDWEST CITIES

THE "AMIC" MACULA DEFICIENCY TESTER

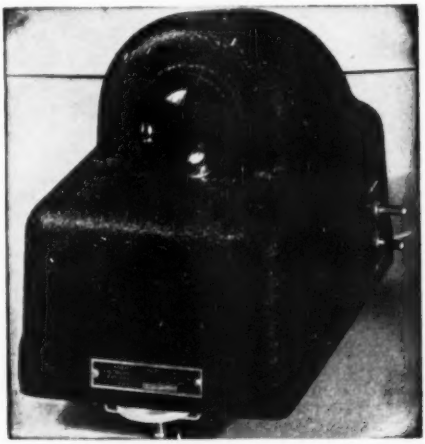
developed by Dr. M. Goldschmidt,
formerly Professor of Ophthalmology, Leipzig University

An instrument to detect early abnormalities of the macula lutea—in a short routine check-up.

As a new instrument of diagnosis, it should belong to the standard equipment of every ophthalmologist.

Write for further information

Recently made available for immediate delivery



AMERICAN MEASURING INSTRUMENTS CORPORATION
21-25 44th Ave., Long Island City 1, N. Y.

If You Wear Glasses and Drive at Night

Notice how reflections from electric signs, street lights and headlights on the surfaces of your glasses are very annoying? These are "ghost images" that hamper clear vision and add to the chore of night driving.

MAY-O-LITE, a hard, durable, thin film of Magnesium Fluoride, helps make night driving easier.

Complete Your Professional Service By Adding

The Best in Sight
MAY-O-LITE
Low Reflection Coating

MAY RESEARCH, INC., Box 1181, Minneapolis 1, Minn.

Northwestern University Medical School

Announces

The establishment of a
THREE YEAR RESIDENCY
in
Ophthalmology

Beginning January 1, 1954 with a new appointment made every six months. Rotation between Wesley, Passavant and Veterans Research Hospitals.

For Further Details Write Department of Ophthalmology

Northwestern University Medical School
303 East Chicago Avenue Chicago

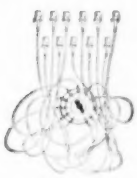
Some people have the nicest garbage!

Yes, those who serve only the finest of foods often have the nicest garbage.

Univis, too, has some very fine garbage. Not food, of course, but lenses good enough perhaps to "get by," but not good enough to measure up to Univis standards which call for an instrument detecting accuracy to 25 millionths of an inch.*

Not everyone has such nice garbage. We're proud of ours. Lenses that are just "good" go to the scrap heap, happily kept small by stringent quality control during production. The ones you get are better—the best in the industry.

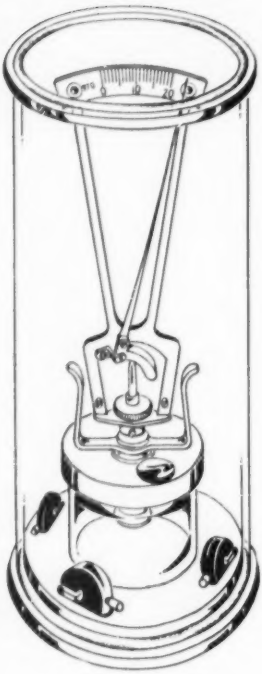
℞ UNIVIS—INSIST ON UNIVIS.



*The latest unique Univis Quality Control Device is the Unichrometer, capable of detecting accuracy to twenty-five millionths of an inch! Your Univis representative will be pleased to describe this device to you

univis

THE UNIVIS LENS COMPANY • DAYTON 1, OHIO



NEW

TONOMETER STERILIZER

ALL PLASTIC CONSTRUCTION, HOLDING COMPLETE TONOMETER AND ACCESSORIES.

PRICE $10.00

ADVANTAGES ARE—

TONOMETER ALWAYS IN POSITION FOR USE.

LESS HANDLING OF INSTRUMENT.

TONOMETER ALWAYS—

CLEAN

DUST FREE

STERILE

MFG. BY

R. O. GULDEN

4920 N. LAWRENCE ST. PHILADELPHIA 20, PA.

Night Driving Demands

Lestra-Lite

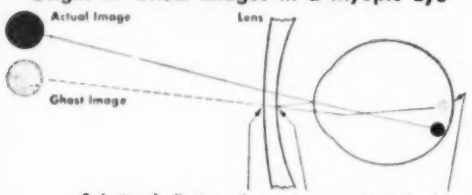
Reg. U.S. Pat. Off.

OPHTHALMIC LENS COATING

"There IS a Difference"

Reflections from eye-glass surfaces are most distracting while driving at night. Light reflected between the front and back lens surfaces and between the cornea and lens surfaces intensifies the glare of oncoming headlights, reducing the driver's visual discrimination. For easier, safer night driving, *always* prescribe Lestra-Lite.

Origin of Ghost Images in a Myopic Eye



Reduction of reflection at these surfaces . . . . . effectively subdues ghost images on retina

FAST LESTRA-LITE SERVICE { Lenses processed and returned via prepaid airmail same day as received.

Write for half-coated Lestra-Lite Sample and Literature.

PACIFIC UNIVERSAL PRODUCTS CORPORATION

158 Vista Avenue • Pasadena 8, Calif.

130 Bush Street • San Francisco 4, California

VISION TEST CHARTS

(A. M. A. Standard)

These charts have been prepared in accordance with the compensation tables adopted by the Section on Ophthalmology of the American Medical Association. The set consists of the following:

1—Distance Test Chart (10½" x 28") with notation of acuity and per cent of visual efficiency. (20/20 or 100% to 20/200 or 20%.), includes three color bars. **$1.00.**

This chart requires a distance of 20 feet for use in direct vision.

(This chart is too large for foreign mailing.)

1 Near Vision Reading Card (5" x 8") with notation of visual acuity and per cent of visual efficiency. (14/14 or 100% to 14/224 or 6.8%.) **40 cents.**

1 Pad of 50 sheets of Industrial Field Charts, printed on both sides. One side of sheet is the Motor Field Chart with table showing efficiency of muscle function in diplopia and gives directions for calculating muscle function. The other side of sheet is the Visual Field Chart showing table, directions and visual field outlines for charting purposes. **75 cents.**

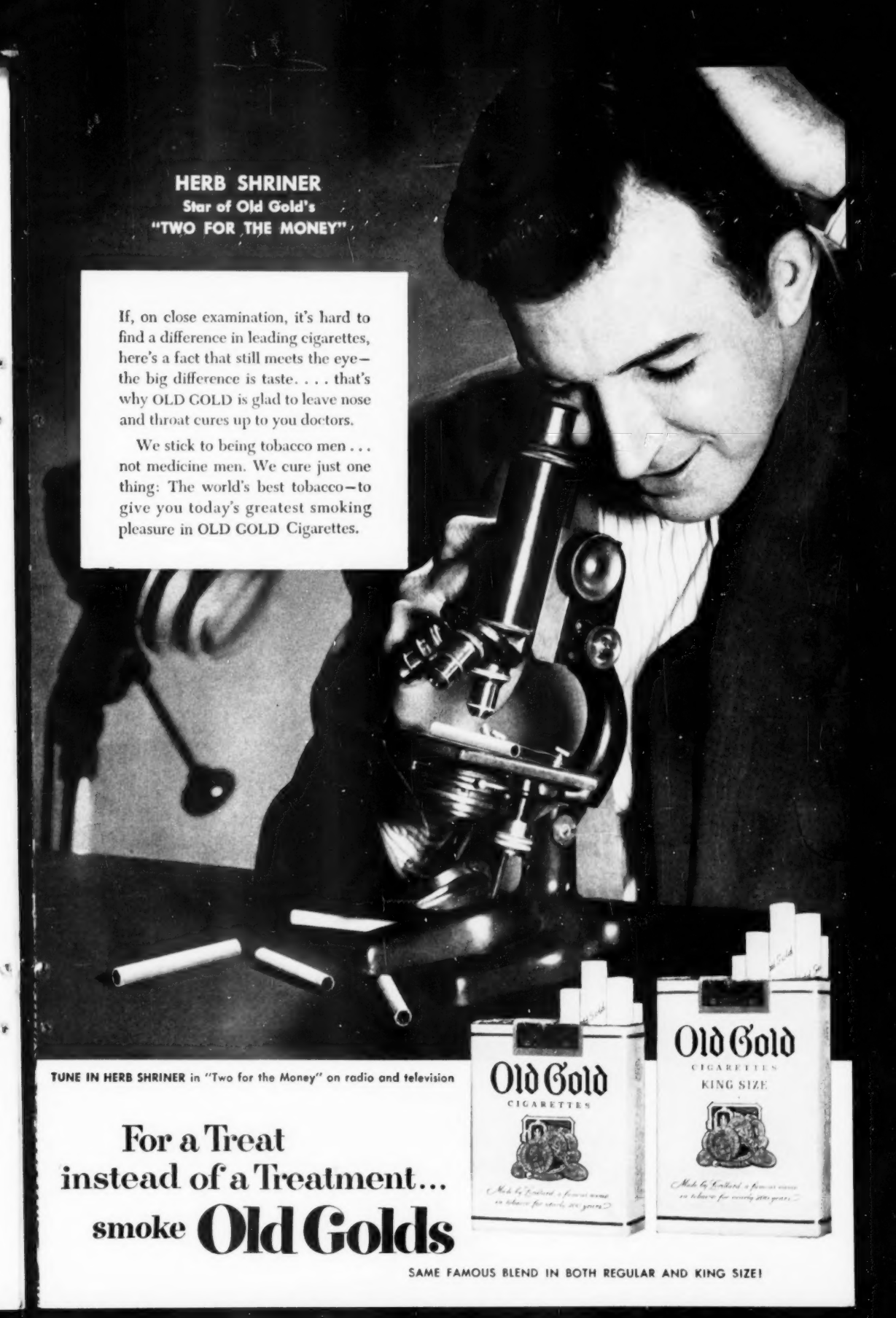
Price for a Complete Set, **$2.00.**

VISION CHART (For School Use)

Contains letters and characters for testing vision of both large and small children. Wall size, 10½" x 28". Price, **$1.00.**

AMERICAN MEDICAL ASSOCIATION

535 North Dearborn Street Chicago 10, Illinois


HERB SHRINER
Star of Old Gold's
"TWO FOR THE MONEY"
If, on close examination, it's hard to find a difference in leading cigarettes, here's a fact that still meets the eye—the big difference is taste. . . . that's why OLD GOLD is glad to leave nose and throat cures up to you doctors.
We stick to being tobacco men . . . not medicine men. We cure just one thing: The world's best tobacco—to give you today's greatest smoking pleasure in OLD GOLD Cigarettes.
Old Gold
CIGARETTES
Old Gold
CIGARETTES
KING SIZE

TUNE IN HERB SHRINER in "Two for the Money" on radio and television

For a Treat instead of a Treatment... smoke Old Golds

SAME FAMOUS BLEND IN BOTH REGULAR AND KING SIZE!

storz
Surgical Instruments

Catalog sent upon request

431b 433 435 435b

Keratoplasty Instruments

431a* Trephine, Corneal Transplant, Castroviejo.

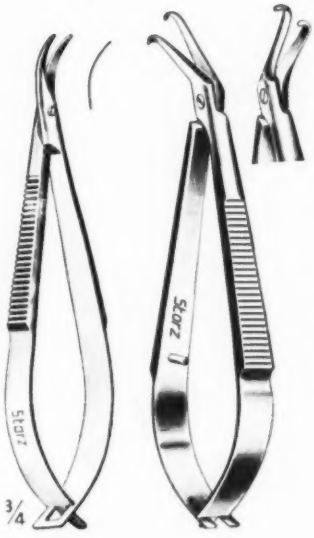
SPECIAL FEATURES:

1. Abrupt bevel extending from cutting edge.
2. Plunger completely fills inside of cutting blade.
3. Stops are curved to adapt to the corneal curvature.
4. One turn of stop moves it 1 mm. for easy adjustment.

Sizes: 5-5½-6-6½-7-8-9-10 and 11 mm.

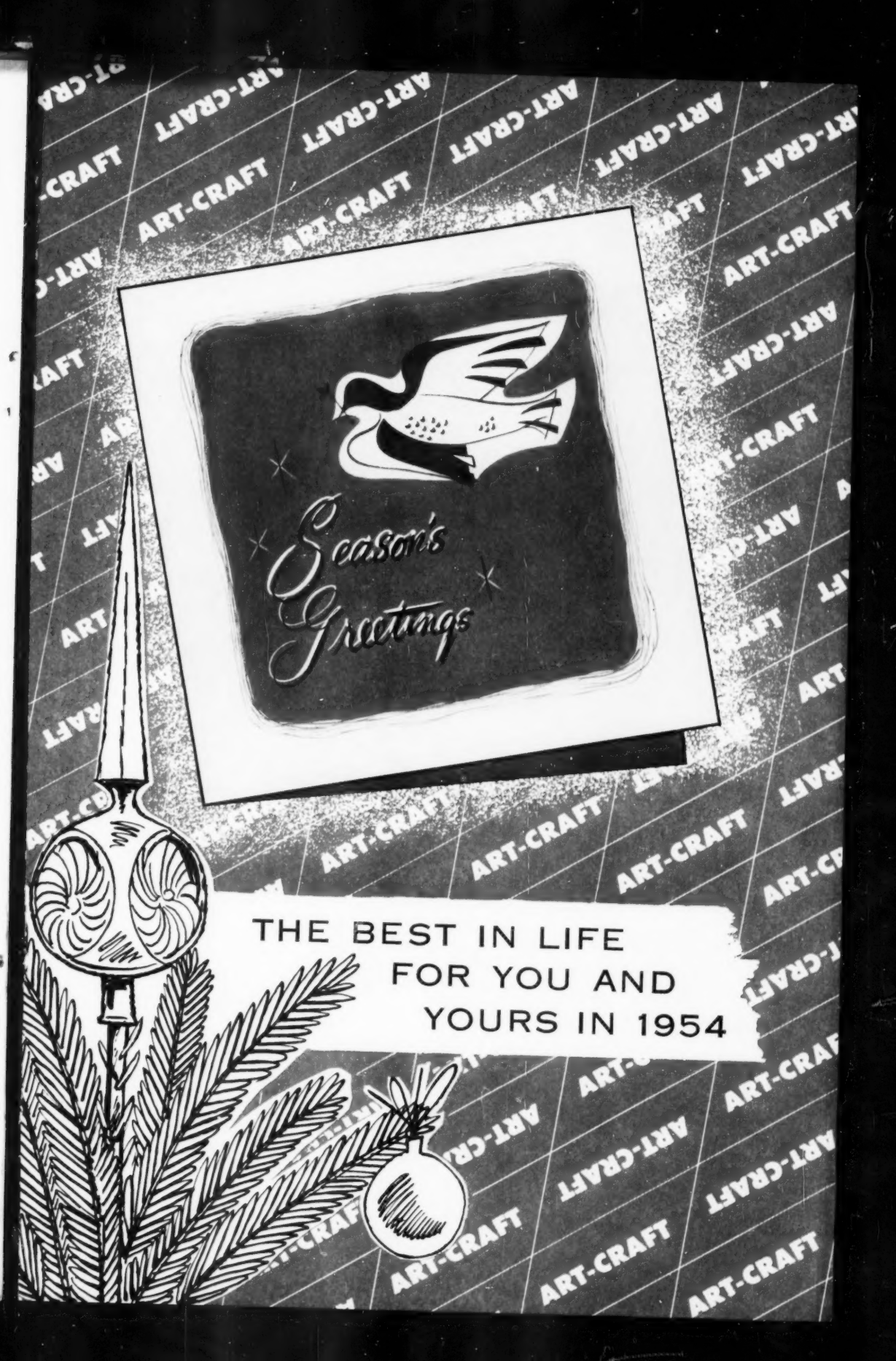
431b*	5 small sizes and handle in plastic case.....	$122.50
432*	4 large sizes without handle in plastic case...	95.00
433*	Single, any size.....Each	20.00
434*	Trephine, Corneal Transplant, GUYTON: permanent inside stop 2 mm. from edge. Made either for dental engine or Elliott chuck handle	7.50
435*	Trephine, Corneal Transplant, KATZIN: one piece with adjustable inside stop and forefinger plate. Extra blades, same size as instrument can be had. Sizes 5 through 10 mm.....Each	20.00
435b*	Trephine, Corneal Transplant, PATON: new model, sizes 5, 6, 7, 8 and 10 mm.....Each	25.00
438*	Scissors, KATZIN: for corneal graft, to complete the corneal section after trephining. Blunt tipped curved end the size of button, curved right and left. Spring action....Each	19.50
475*	Scissors, Corneal, CASTROVIEJO: curved..	20.50

*DESIGNATES STAINLESS STEEL



475 438

Storz Instrument Company
4570 AUDUBON AVENUE ST. LOUIS 10, MISSOURI


ART-CRAFT
Season's Greetings
THE BEST IN LIFE
FOR YOU AND
YOURS IN 1954

Wide Application in Ophthalmology

new

Neo-Synephrine hydrochloride ophthalmic viscous solution 10% in collapsible tubes of ⅛ oz.

spreads evenly
adherent
clear
stable

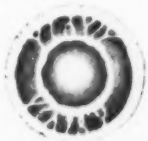
NEO-SYNEPHRINE®
HYDROCHLORIDE

WINTHROP-STEARNS INC.
NEW YORK 18, N.Y. • WINDSOR, ONT.

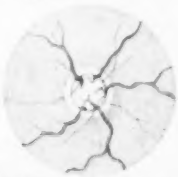
Neo-Synephrine, trademark reg. U. S. & Canada, brand of phenylephrine

CONJUNCTIVITIS
1/8% solution.
For rapid relief of congestion, itching, smarting and lacrimation.

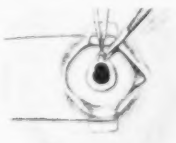
REFRACTION, OPHTHALMOSCOPY
2.5% solution.
For prompt and short acting mydriasis virtually free from cycloplegia.



UVEITIS, POSTERIOR SYNECHIAE
10% solution (plain or viscous) or 10% emulsion.
For freeing recently formed posterior synechiae as well as for prevention of synechiae formation in uveitis (with atropine).



GLAUCOMA (certain cases and tests)
10% solution (plain or viscous), 10% emulsion or 2.5% solution.
For temporary reduction of intra-ocular tension and for the provocative test for angle block.



SURGERY
2.5% solution or 10% solution (plain or viscous).
For short acting powerful mydriatic effect, applied 30 to 60 minutes preoperatively.

THIS PUBLICATION
IS REPRODUCED BY AGREEMENT
WITH THE PUBLISHER. EXTENSIVE
DUPLICATION OR RESALE WITHOUT
PERMISSION IS PROHIBITED.